Wind Energy Department annual progress report 2002

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Wind Energy Department
Annual Progress Report 2002

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The new Test Station at Høvsøre

Risø National Laboratory
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Contents

Introduction

Research and development activities of the Wind Energy Department range from boundary layer meteorology, fluid dynamics, and structural mechanics to power and control engineering as well as wind turbine loading and safety. The overall purpose of our work is to meet the needs for knowledge, methods and procedures from government, the scientific community, and the wind turbine industry in particular. Our assistance to the wind turbine manufacturers serve to pave the way for technological development and thus further the exploitation of wind energy worldwide. We do this by means of research and innovation, education, testing and consultancy.

In providing services for the wind turbine industry, we are involved in technology development, design, testing, procedures for operation and maintenance, certification and international wind turbine projects s as well as the solution of problems encountered in the application of wind energy, e.g. grid connection. A major proportion of these activities are on a commercial basis, for instance consultancy, software development, accredited testing of wind turbines and blades as well as approval and certification in co-operation with Det Norske Veritas.

The department's activities also include research into atmospheric physics and environmental issues related to the atmosphere. One example is the development of online warning systems for airborne bacteria and other harmful substances.

The department is organized in programmes according to its main scientific and technical activities.

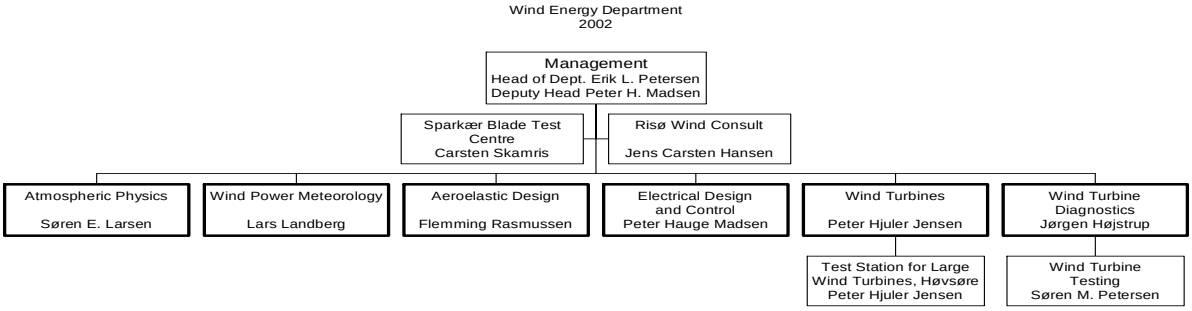
Research programmes

- Aeroelastic Design, AED
- Atmospheric Physics, ATM
- Electrical Design and Control, EDS
- Wind Power Meteorology, VKM
- Wind Turbines, VIM
- Wind Turbine Diagnostics, VMD

Commercial programmes

- The Test Station for Large Wind Turbines, Høvsøre, HØV
- Risø Wind Consult, INR
- Wind Turbine Testing
- Sparkær Blade Test Centre

In 2002 the department employed a total of 109 man-years, two of which involved PhD students and post-doctoral researchers. The departmental structure by the end of 2002 is illustrated below.



Aeroelastic Design
The key issues of this programme are the development and use of aeroelastic codes, computational fluid dynamics (CFD) codes and software design tools for wind turbine blades and aerofoils. The codes are used for establishing design load bases for wind turbines, furthering the development of the three-bladed wind turbine concept and developing new wind turbine concepts. In addition, the programme undertakes wind tunnel measurements of aerofoil section flows.

Atmospheric Physics
This programme concentrates on basic research into boundary-layer meteorology and atmospheric turbulence. We also study environmental problems related to the transport of airborne pollutants and turbulent exchange of matter during interaction between the atmosphere and terrestrial (or sea) surfaces.

Electrical Design and Control
An important purpose of this programme is to lower the cost of wind energy by optimizing the wind turbine as well as the grid interface and power system operations. Our research involves topics such as control concepts for wind turbines, electrical components, grid connection and large-scale wind energy penetration, hybrid power supply systems and energy storage combined with renewable energy sources.

Wind Power Meteorology
Wind Power Meteorology is aimed at the assessment of wind resources for power production and wind loads on wind turbines and other constructions. The programme comprises development of models and software, field measurements and in-house as well as commissioned assessment studies.

Wind Turbines
This programme conducts strategic and applied research into wind turbine loading and safety, experimental verification, technical and economic analysis of the utilization of wind energy in grids and in hybrid energy systems. Research within this programme supports our consultancy activities in wind energy projects for Danish and international authorities, organizations, banks and investors. It also supports our participation in the development of international standards.

Wind Turbine Diagnostics
In this programme, research is aimed at the development of instrumentation and new methods for experimental determination of wind turbine characteristics, including test methods for the wind turbine industry. This unit also provides the departmental expertise in organizing and conducting field meteorological measurements, providing instruments as well as data systems and data management.

The Test Station for Large Wind Turbines, Høvsøre
This is a commercial programme, and the objective is to establish a test facility near the west coast of Jutland for large wind turbines. This area has excellent conditions with respect to high wind speeds and straightforward wind patterns that are easy to model due to the flat terrain. We can therefore verify both the performance and the wind turbine design bases for all operating conditions in relation to large wind turbines.

Risø Wind Consult
This is another commercial programme, and in this case we aim to utilize the knowledge and state of the art tools available at Risø in providing consultancy and technical advice for international projects concerning the development and application of wind power technology.

Wind Turbine Testing
Being a commercial programme, Wind Turbine Testing offers its expertise in measuring techniques for wind turbine testing at Risø or field measurements for manufacturers.

Sparkær Blade Test Centre
The commercial Sparkær Blade Test Centre programme is accredited for static and dynamic fatigue testing of wind turbine blades and provides this service to Danish blade manufacturers at our test centre in Sparkær.

This annual report presents the department and our results in 2002, including programmes and services, research highlights, and other achievements. The report also presents lists of publications, lectures, committees and staff members.

Additional information on the department and our activities can be found on the web; http://www.risoe.dk/vea/. The department's web site is frequently updated.

Highlights 2002

Professional achievements
The Numerical Wind Tunnel has had a major breakthrough this year, mainly facilitated by the development of computational power. We now provide a commercial service for the wind turbine manufacturers, and VEA uses the numerical wind tunnel both for the design of airfoils and for investigating complex flow scenarios such as yaw. We can now perform analysis with a direct coupling between individual flow calculations and structural response, enabling us to perform full aeroelastic computation and determination of aerodynamic damping of the entire rotor. We may also conduct aerodynamic calculations on the entire rotor by means of detached eddy simulation (DES).

Our newly developed computational design tool for modal analysis, the HAWC-Modal, has been marketed and was well received by the wind turbine industry. In the wake of the HAWC-Modal, a new method for experimental investigations of dynamic stability of the turbine has been developed and made available to the industry.

We have developed a new method of analysis and a model for large deflections of wind turbines in complex terrain, a tool much needed by manufacturers for the analysis of large flexible wind turbines.

The Wind Atlas Analysis and Application Program has reached user number 1.000. Version 8 is now ready for marketing, presenting a new feature that will calculate wake effects in wind farms. This group has also completed the new Wind Atlas for the Gulf of Suez, sponsored by Danida. The wind atlas is based on ten years of data from the Suez region, and is a fundamental prerequisite to the introduction of wind power on a large scale in Egyp
The further development of WasP has been initiated, and we expect to see a new and improved version of WasP in about three years time. A new and improved flow model in particular may bring about major improvements.

In 2002, we embarked upon the production of a global renewable energy atlas, funded by the United Nations Environment Programme/Global Environment Facility (UNEP/GEF). SWERA, the Solar and Wind Resource Atlas, will cover 10 to 15 countries around the world, and we are currently working on a proposal to UNEP for the full-scale project. Our partners in this collaboration are the National Renewable Energy Laboratory (NREL), USA, and The Energy and Resources Institute (TERI), India.

The Prediktor program for short-term prediction of energy production from wind farms is currently being used for several commercial projects in Ireland, Texas and California.

We have concluded the calibration of the safety level and partial safety coefficients for the third edition of the international standard IEC 61400-1 (wind turbine design requirements).

This year also yielded new models and an improved understanding of the simulation of the electrical interaction between large wind farms and the grid. We have been able to simulate effectively the collective effect of power fluctuations from individual wind turbines on the dynamic stability of the grid.

Our terrain roughness model, GIS, based on satellite data and developed in a collaboration with the Danish Meterological Institute and others, has already proved superior to existing models when used in weather forecasting simulations. This was the last of the funding from the former ESA follow-up programme, and the published results have been widely commended.

The section of VEA working with dispersion of trace elements in the atmosphere and liquids have found the functions describing their distribution to be surprisingly simple and homogeneous. They have formulated a new and remarkably simple theory, that encompasses experiments on a scale from the humble basement experiment at VEA to a considerable number of atmospheric LIDAR measurements.

Instrument development

We pride ourselves on having developed the world's most exact and reliable cup-anemometer, and apparently others agree, since the 1,000th instrument was sold from Risø this year.

Satellite-based measuring equipment, that will transmit measuring data from all over the world, has been developed and implemented in collaboration with a Norwegian company, Aanderaa Instruments.

At our Sparkær test station, we have developed and implemented a modal analysis method for measurements on blades. Four research projects have been initiated, dealing with accelerated testing and damage development, detection of fracture growth, verification of buckling calculations, and modal analysis respectively.

This year has seen an increase in commercial activities. As well as a growth in the number of consulting tasks in the field of wind energy, we have also succeeded in improving collaboration on consultation assignments.

Collaboration and infrastructure

The Wind Energy Department, which used to be scattered around several locations at Risø has now been brought together in two adjacent and newly renovated buildings, thus realizing the Wind Energy Centre at Risø. The centre was inaugurated in 2002. The move has already proved successful in facilitating intradepartmental communication. Apart from our Risø site, the department comprises two test stations in Jutland.

The Danish Research Consortium for Wind Energy was established with Denmark's Technical University, Aalborg University and DHI Water and Environment as partners. By joining forces in this consortium, we will further enhance collaboration among science, education and industry. Initially, the consortium has fathered a research school, DAWE; Danish Academy in Wind Energy.

This year we initiated the formation of a profesional network specializing in composite materials. The recently established consortium for wind energy also participates as do members of the Danish Wind Industry Association.

Developing the organization

A new collaboration has been established between the Sparkær Centre and Wind Turbine Diagnostics (VMD). Together they will carry out wind measurements and wind turbine testing. Sparkær has taken over operations at Høvsøre and has now commenced cooperation with other VEA sections on the instrumentation and measuring of wind turbines.

A new meteorological research programme has been initiated jointly by ATM and VKM. This combination of fundamental and applied research is proving extremely useful.

A new research group – Wind Energy Systems – has been formed, based on Electric Design and Control (EDS) and Risø WindConsult (INR).

Education

This year, we established the international research academy, Danish Academy of Wind Energy (DAWE), thus providing a national framework for the education of scientists at PhD-level for the wind energy field.

In the former wind turbine hall we have now assembled a number of facilities for experiments with combined energy systems. We hope to use these facilities in the future for student projects as well as departmental research and development.

The department has now formalised our educational activities. In the future, the department will host a maximum of seven PhD scholarships, our staff will teach at several universities and other institutions of higher learning, and we will host master's degree projects. These activities are linked to both the Danish Research Consortium for Wind Energy and DAWE. The first four students have been chosen, with one being partly financed by Vestas Wind Systems A/S.

New Test Station for Large Wind Turbines

On 18 December 2002, VEA celebrated the inauguration of our new test station at Høvsøre, Jutland.

The roadworks and constructions at the new Test Station for Large Wind Turbines at Høvsøre started in summer that year. The location is just north of the Nissum Firth on Jutland's west coast, where the wind is fierce across a flat terrain, and therefore well-defined – and this is exactly what the we need in order to test the safety and endurance of large wind turbines under extreme wind conditions.

Today's aeroelastic calculation models are very advanced, but when the wind speed exceeds 15 metres per second, the uncertainty as to how the wind turbines will perform with respect to safety and power performance – increases.

Danish wind turbine manufacturers have taken a great interest in the Test Station right from the start. To industry, this is an opportunity to test their product and subsequently optimize design, so that future wind turbines will be well adapted to extreme weather conditions, and thus competitive on a worldwide scale. To the Wind Energy Department, the Test Station represents better research facilities, which will reflect upon the improvement of calculation models and the development of more reliable and cost-efficient wind turbines.

When the test facility is up and runnning, there will be a maximum of five wind turbines being tested simultaneously. The investment will all be paid back by revenue from clients within five years. The major Danish manufacturers, Vestas Wind Systems A/S, NEG Micon, Bonus A/S

and Nordex have all entered agreements on using the test facility within that period, and furthermore, Vestas has entered an agreement to use the fifth test bed for a period of one to two years.

Wind turbines at the test facility will reach a maximum height of 165 m from the ground to the tip of the upper blade, and measuring-masts erected in front of the test stands will match the hub height of the turbines. This poses a risk to local air traffic, and two 165 m masts equipped with flashing lights have been erected for the sole purpose of warning off helicopters and other aircraft, following requirements from the Danish Civil Aviation Administration.

An important part of this process has been our communication with the local community at Høvsøre. At several meetings, Risø has presented our plans for the test station, and there has been ample opportunity to discuss all aspects of future operations.

Programmes and Projects

Aeroelastic Design, AED

Research programme
Head of Programme; Flemming Rasmussen

The objective of this research programme is to develop new knowledge and models in aerodynamics, structural dynamics, aeroelasticity, and design loads for application in the design and optimisation process of present-day and future wind turbine concepts.
Mid-term goals are to develop the following;

- An analytical and numerical tool – 'the numerical wind tunnel' – for aeroelastic design and optimisation of wind turbines as well as an experimental wind tunnel facility for verification.
- An aeroelastic design tool capable of simulating detailed response and stability for flexible MW wind turbines with control.
- A design complex for the development of current as well as new wind turbine concepts.

The means to reach these goals are long-term strategic and applied research and development in the fields of experimental and numerical aerodynamics as well as aeroacoustics (CFD and CAA), structural dynamics, areoelasticity, stability and design basis.

AED projects

Wind Turbine Blade Aerodynamics and Aeroelastics (Knowblade)
Programme: AED, project no. 1110033-00, start date 1.12. 2001, end date 30.11. 2004.
● The objective of this project is to fill in important knowledge gaps in the wind turbine community by applying Navier-Stokes solvers to a series of unsolved problems. We plan to
• improve power prediction by including laminar/turbulent transition models and advanced turbulence models in Navier-Stokes (NS) solvers,
• develop and implement models for aerodynamic accessories in the wind turbine industry in existing NS-solvers,
• extend present-day NS aeroelastic tools to full 3D blade configurations and investigate the aerodynamic damping properties of 2D aerofoils with various aerodynamic accessories, and
• investigate industrial flow details such as different tip-shapes and loads during standstill.
Altogether this will upgrade the competence of the European wind turbine industry as regards blade design.
Partners: Foundation for Research and Technology (FORTH), Institute of Applied and Computational Mathematics, Greece,
Vrije Universiteit Brussel, Faculty of Applied Sciences, Belgium,
German Aerospace Centre, Institute of Aerodynamics and Flow Technology, Germany,
LM Glasfiber A/S, Denmark,
Swedish Defence Research Agency (FOI), Dept. of Computational Physics, Sweden,
Technical University of Denmark, Dept. of Mechanical Engineering, Denmark,
Centre for Renewable Energy Sources (CRES), Div. of Renewable Energy Sources, Greece,
National Technical University of Athens (NTUA), Faculty of Mechanical Engineering, Greece.

Sponsor/client: European Commission.
Contact: Niels N. Sørensen, niels.soerensen@risoe.dk, tel. +45 4677 5053.

Application, Demonstration and Further Development of Advanced Aerodynamic and Aeroelastic Models
Programme: AED, project no. 1110036-00, start date 1.7. 2002, end date 31.12. 2003.
● This project runs for 18 months and is based on a previous five-year research programme on aeroelasticity.
The latest computer models in aerodynamics and aeroelasticity (referred to as the design complex) are used to analyse three MW turbines simultaneously. Subsequently, Risø and DTU in cooperation with the manufacturers will estimate how the resulting analysis may affect turbine design. Design improvements based on the new design complex will be identified for later implementation by manufacturers. During design analysis there will be an exchange of knowledge between Risø/DTU and the manufacturers to the benefit of ongoing development of the design complex.
Partners: Technical University of Denmark (DTU),
Bonus Energy A/S, Denmark,
LM Glasfiber A/S, Denmark,
NEG Micon A/S, Denmark,
Vestas Wind Systems A/S, Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Christian Bak, christian.bak@risoe.dk, tel. +45 4677 5091.

Aeroelastic Stability and Control of Large Wind Turbines (STABCON)
Programme: VEA, project no. 1110038-01, start date 1.11. 2002, cont.
● This project deals with the development and verification of advanced aeroelastic stability tools, including the wind turbine control system. These tools are to be applied to the analysis and design of large wind turbines throughout the European wind turbine industry. We explore new ideas and potential for the application of active aeroelastic controls, not only in order to maintain or enhance power but also to increase damping and control/reduce loads on vital components. Today's multi-megawatt wind turbines represent an increased risk of aeroelastic instability as designs are stretched to the limit. The answer to this problem is to increase the reliability of design methods and tools, and to address stability problems specifically as an integrated part of the design process.
Partners: Energy research Centre of The Netherlands (ECN), Netherlands,
Centre for Renewable Energy Sources (CRES), Greece,
National Technical University of Athens (NTUA), Greece,
Technical University of Denmark (DTU), Denmark,
Universität Stuttgart, Germany,
Delft University of Technology, Netherlands,
NEG Micon A/S, Denmark.
Sponsor/client: European Commission.
Contact: Peter Fuglsang, peter fuglsang@risoe.dk, tel. +45 4677 5071.

Various Commercial Tasks
Programme: AED, project no. 1110400-00, start date 20.11. 1997, cont.
● This activity represents a variety of commercial projects, requested primarily by the wind turbine industry. They are small- and large-scale projects in line with research activities. These projects serve three objectives:
• They represent a dedicated investigation,
• they act as an efficient way of transferring new knowledge to industry, and

• they render direct and valuable feedback and inspiration for future research.
Partners: Manufacturers in the Danish wind turbine industry, Denmark.
Sponsor/client: Manufacturers in the Danish wind turbine industry, Denmark.
Contact: Flemming Rasmussen, flemming.rasmussen@risoe.dk, tel. +45 4677 5048.

Database on Wind Characteristics
Programme: AED, project no. 1110024-00, start date 1.1. 1999, cont.
● The purpose of this project is to provide wind turbine designers and others with a source of reliable, actual wind field time series observed in a wide range of wind climates and terrain types all over the world. All data are presented in a common format. Organizing the databank comprises the following activities:
• maintaining the database in order to ensure that data as well as hardware and software will be online and available at all times,
• extending the databank with meteorological data from countries outside Europe and from sites and wind climates that are not already well represented,
• broadening database search and analysis facilities, and
• communicating the contents of the databank and the possibilities for use of the data material.
The database is located at http://www.winddata.com.
Partners: Governmental institutions in USA, Japan, Norway, Sweden and the Netherlands.
Sponsor/client: International Energy Agency (IEA); Implementing Agreement on Wind Turbines, Annex XVII.
Contact: Gunner Larsen, gunner.larsen@risoe.dk, tel. +45 46775056.

Damping of Blade and Tower Vibrations
Programme: AED, project no. 1110027-00, start date 17.3. 2000.
● The aerodynamic damping of the various wind turbine mode shapes is very important for load response. We are developing a method for measuring damping at different wind speeds. This method will support the identification of input parameters for aeroelastic load calculations and thus reduce uncertainty of the resulting loads.
Partners: Bonus Energy A/S, Denmark,
LM Glasfiber A/S, Denmark,
Technical University of Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Kenneth Thomsen, kenneth.thomsen@risoe.dk, tel. +45 4677 5052.

Gearbox Loadings and Wind Turbine Dynamics
Programme: AED, project no. 1110029-00, start date 28.12. 2000, end date 31. 12 2003.
● Design loads for wind turbine gearboxes are usually established on the assumption that only static external loads will be applied. The objective of this project is to investigate the significance of the gearbox as an integrated part of the wind turbine's dynamic system and to clarify the importance of inertia loads due to gearbox accelerations. A detailed structural modelling of the gearbox in a nacelle is carried out with MSC.Adams software. Simultaneously, measurements are being carried out on a real wind turbine in order to identify external loads on the gearbox. Results will serve as recommendations for inclusion of inertia loads in gearbox design.
Partners: NEG Micon A/S, Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Kenneth Thomsen, kenneth.thomsen@risoe.dk, tel. +45 4677 5052.

Model Rotor Experiments under Controlled Conditions (MEXICO)
Programme: AED, project no. AED 1110030-00, start date 1.1. 2001.
● The main objective of the MEXICO project is to significantly reduce the uncertainty of design calculations by providing an experimental database, obtained by measurements from a 5 m diameter model rotor of a wind turbine, running under the controlled conditions of a wind tunnel. There will be detailed pressure measurements on one blade of the model rotor, combined with flow field measurements and flow visualization. The insight gained from these experiments will be used to improve and validate design tools.
Partners: National Aerospace Laboratory (NLR), Netherlands,
Delft University of Technology (TUD), Netherlands,
Polymarin, Netherlands,
Technion – Israel Institute of Technology, Israel,
Technical University of Denmark (DTU), Denmark,
The Swedish Defence Research Agency (FOI), Division of Aeronautics FFA, Sweden,
Centre for Renewable Energy Sources (CRES), Greece,
National Technical University of Athens (NTUA), Greece.
Sponsor/client: European Commission.
Contact: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk, tel. +45 4677 5047

Wind Turbine Rotor Blades for Enhanced Aeroelastic Stability and Fatigue Life Using Passively Damped Composites (DAMPBLADE)
Programme: AED, project no. 1110031-00, start date 30.1. 2001.
● This project deals with the design, manufacture, and testing of passively damped composite wind turbine blades. The purpose is to reduce vibrations and thereby increase the lifetime og modern wind turbines by utilizing high structural damping of the blades. The project consists of various tasks:
• Analytical and experimental investigations of structural damping mechanisms of composites,
• development of theoretical models for predicting the effect of increased structural damping on turbine response and stability,
• design and manufacture of blades with desired properties, and finally
• a large-scale field test of performance.
Partners: Centre for Renewable Energy Sources (CRES), Greece,
Energy research Centre of the Netherlands (ECN), Netherlands,
Foundation for Research and Technology – Hellas (FORTH), Institute of Chemical Engineering and High Temperature Chemical Processes, Greece,
University of Patras, Greece,
Polymarin, Netherlands,
Geobiologiki S.A, Greece,
Technical University of Denmark, Dept. of Mechanical Engineering, Denmark.
Sponsor/client: European Commission.
Contact: Morten Hansen, morten.hansen@risoe.dk, tel. +45 4677 5077.

Aeroelasticity EFP 2001
Programme: AED, project no. 1110032-00, start date 1.7. 2001, end date 31.6. 2002.
● This project concerns one year of a five-year research programme on aeroelasticity. The main objectives for the present period are the following:
• Development of a design tool for the analysis of dynamic stability,

• investigations of blade tip aerodynamics and blade tip design on the basis of 3D CFD (computational fluid dynamics) computations,
• publication of an aerofoil catalogue,
• load reduction by means of new control strategies, and
• aero-acoustic modelling of noise propagation.

We work in close collaboration with the industry, and a number of current problems and potential developments relevant to the industry will be dealt with.
Partner: Technical University of Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk, tel. +45 4677 5047.

Atmospheric Physics, ATM

Research programme
Head of Programme; Søren E. Larsen

The objective of this programme is to contribute new knowledge of boundary-layer meteorology, climatology and atmospheric turbulence with respect to the exploitation of wind energy and to the description of transport of airborne substances.
Mid-term goals are
- to develop measuring principles and models for studying the atmospheric boundary layer with reference to wind energy and environmental issues,
- to develop, validate and apply atmospheric dispersion models, and
- to develop a boundary-layer meteorological description of the nearshore area including wind, waves, roughness and thermal conditions in relation to wind power, wind load and exchange of pollutants.

This is to be obtained by a long-term theoretical and experimental research effort into boundary-layer meteorology, turbulence and climatology.

ATM projects

Aujeszky's Virus
Programme: ATM, project no. 1100006-00, start date 1.1. 1990, cont.
- This project concerns the development and maintenance of a real-time airborne virus attack warning system based on an on-line meteorology tower at Kegnæs in the south-western part of Denmark. The virus in question is Aujeszky's virus, for which pigs are the natural host.

Partners: Danish Bacon and Meat Council, subsidiary of Danske Slagterier, Denmark.
Sponsor/client: Danish Bacon and Meat Council, Denmark.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

Ulborg
Programme: ATM, project no. 1100007-00, start date 1.9. 1990, cont.
- This is a study of forest productivity correlated to water balance (i.e. precipitation and evapotranspiration), nutrient balance, micrometeorology and air pollution. Risø's contribution to the project lies in the field of micrometeorology, supporting flux estimates of water vapour, CO_2, and other constituent fluxes (dry deposition). The study is part of the pan-European programme for the intensive monitoring of forest ecosystems. Two other forest sites (Linnet and Frederiksborg) have been equipped with less intensive meteorological instrumentation.

Partners: Botanical Institute, University of Copenhagen, Denmark,
National Environmental Research Institute (DMU), Denmark,
the Danish Forest and Landscape Research Institute (FSL), Denmark,
and similar research institutes from another 32 European countries.
Sponsor/client: European Commission, Directorate-General for Agriculture,
the Danish Forest and Nature Agency (SNS), Denmark.
Contact: Niels Otto Jensen, n.o.jensen@risoe.dk, tel. +45 4677 5007.

EuroFlux
Programme: ATM, project no. 1100018-00, start date 1.1. 1996, cont.
● The main task of this project is to carry out long-term eddy correlation measurements of CO_2 and water vapour fluxes over European forests. Main objectives are
• to provide useful parameters for global and regional scale modellers and analyse the variables that determine energy partitioning by forests in different climatic zones, and
• to determine the sink strength for carbon in European forests as well as the factors governing gains and losses – including differing composition of vegetation in various climate regions.
A specific Risø interest is the development of an improved soil/vegetation/atmosphere transfer (SVAT) model.
This project is linked to the global FluxNet: http://daac.ornl.gov/FLUXNET/.
Partners: Dept. of Forest Resources and Environment, Università della Tuscia, Italy, (project co-ordinator),
and about 20 other research institutes from EU countries.
Sponsor/client: European Commission, Directorate-General for Research, FP5.
Contact: Niels Otto Jensen, n.o.jensen@risoe.dk, tel. +45 4677 5007.

SFINCS
Programme: ATM, project no. 1100046-00, end 2002.
● The purpose of the SFINCS project (Surface Fluxes in the Climate System) is to improve the parameterization of the atmospheric boundary layer in climate models and models for weather forecasts. The project focuses particularly on strong stable as well as unstable conditions and on aggregation. Work includes theoretical analysis, comparison with measurements and implementation in numerical models.
Partners: Uppsala University, Sweden,
Max Planck Institute for Meteorology, Germany,
National Observatory of Athens (NOA), Greece,
Institute of Atmospheric Physics, Academy of Sciences, Russia.
Sponsor/client: European Commission, Fifth Framework Programme.
Contact: Søren E. Larsen, soeren.larsen@risoe.dk, tel. +45 4677 5012.

AutoFlux
Programme: ATM, project no. 1100051-1, end 2002.
● The AutoFlux project aims to develop and test an autonomous measuring station for atmospheric fluxes of momentum, latent and sensible heat, and CO_2. The stations are planned for unattended operation from remote stations or from Voluntary Observing Ships (VOS) in commercial sea transport. The project involves the development and construction of instruments as well as systems. The fluxes in question are mainly from turbulence measurements by the dissipation method.
Partners: Uppsala University, Sweden,
Southampton Oceanography Centre, United Kingdom,
Gill Instruments Ltd., United Kingdom,
KNMI (the royal Dutch meteorological institute), Netherlands,
Centre d'étude des Environnements Terrestre et Planétaires (CETP), Centre National de la Recherche Scientifique (CNRS), France
Sponsor/client: European Commission, Fifth Framework Programme; Energy, environment and sustainable development, sustainable marine ecosystems.
Contact: Morten Nielsen, n.m.nielsen@risoe.dk, tel. +45 4677 5022.

Understanding the Role of Vehicle Emissions in the Formation of Secondary Organic Aerosols (DMI Wind Climate)
Programme: ATM, project no. 1100053-1, start date 1.1. 1999, cont.
● This project is a collaboration with Ford Forschungszentrum Aachen. The main focus is on the development of explicit chemistry modules for describing the production of condensable molecules through atmospheric oxidation of volatile organic compounds. These modules are being compared with two-parameter absorption approaches currently used in atmospheric chemistry modules.
Partners: None.
Sponsor/client: Ford Forschungszentrum Aachen, Germany.
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

Sat-Map Climate
Programme: ATM, project no. 1100054-1, start date 1.4. 1999, end date 30.3. 2002.
● This project concerns the validation of wind and temperature data from synoptic weather stations and validation of surface flux data from land- and ocean-based meteorology masts in Denmark. Satellite-based maps of land surface roughness, albedo and vegetation state have been area-averaged and input to HIRLAM (High Resolution Limited Area Model). An improvement in weather forecasting using aggregated roughness values was demonstrated for winds and the forecasting of land/sea breezes was also improved by using satellite-based sea surface temperatures. This work is prerequisite to improving predictions of global climate changes.
Partners: Danish Meteorological Institute, Denmark,
University of Copenhagen, Denmark.
Sponsor/client: Danish Research Agency (Forskningsstyrelsen), Denmark.
Follow-up to European Space Agency (ESA) project.
Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk, tel. +45 4677 5014.

LSMC 2000
Programme: ATM, project no. 1100055-3/4, start date 1.10. 1999, cont.
● The purpose of this project is to apply the ARGOS NT (a Danish support system for decision-making in case of nuclear accidents) version Local Scale Model Chain (LSMC) to 'Danish national scale' (horizontal: 400 km x 400 km, vertical: 2 km). This requires several enhancements of today's model: Trifurcating, vertical shear rise, improved treatment of inversion layer effects, the development of a new resistance method for dry deposition, and a new plume rise module as well as coupling to GSF's food chain module and restructuring of RIMPUFF (Risø Mesoscale Puff Model).
Partners: Danish Emergency Management Agency, Denmark,
Prolog Development Center A/S, Denmark,
Danish Meteorological Institute, Denmark
the GSF National Research Center for Environment and Health (GSF), Germany.
Sponsor/client: Danish Emergency Management Agency, Denmark.
Contact: Søren Thykier-Nielsen, soeren.thykier@risoe.dk, tel. +45 4766 5026.

EU MEAD
Programme: ATM, project no. 1100062-1, start date 1.2. 2000, cont.
● The overall objective of MEAD (Marine Effects of Atmospheric Deposition) is to describe the effects of atmospheric nitrogen deposition on coastal water biogeochemistry. We have developed a high-resolution atmospheric model, describing the complex meteorology and atmospheric nitrogen chemistry of the coastal zone and coupled this to a hydrodynamic biogeochemical model of the Kattegat so as to assess the impact of atmospheric deposition events. Simultaneously, fluxes from

field experiments have been sampled in order to parameterize these models. Furthermore, a retrospective analysis of present atmospheric deposition, phytoplankton abundance and satellite imagery data takes place to investigate any links between atmospheric nitrogen deposition and bloom development.
Partners: National Environmental Research Institute (DMU), Denmark,
University of East Anglia, England,
Stockholm University, Sweden,
Göteborg University, Sweden.
Sponsors: European Commission, Fifth Framework Programme; Energy, environment and sustainable development.
Contact: Lise Lotte Sørensen, lotte.geern@risoe.dk, tel. +45 4677 5015.

DERA Coastal Effects
Programme: ATM, project no. 1100063-1, start date 1.3. 2000, cont.
● This project concerns the development of a new sea breeze wind model, based on the LinCom (linearized computation) flow model equations for conservation of momentum, mass and heat. The new model will be used for assesment of coastal dispersion and for coastal wind resource estimation.
Partners: (Defence Evaluation and Research Agency, DERA), now Defence Science and Technology Laboratory (DSTL), United Kingdom.
Sponsor/client: DERA, now DSTL, United Kingdom.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

CEPROS Airborne Disease Spread
Programme: ATM, project no. 1100064-1, start date 16.1. 1999, cont.
● In cooperation with the Danish Veterinary Institute, we seek to establish a simple design tool – based on RIMPUFF (Risø Mesoscale Puff Model) – for optimal layout of piglet farmhouses in order to minimise airborne disease transmission between units. As part of this project, we are also responsible for the maintenance of real-time, on-site meteorological measurements during field tests, where airborne virus is being discharged among containers with piglets.
Partners: Danish Veterinary Institute (DVI), Denmark
Sponsor/client: Research Centre for the Management of Animal Production and Health (CEPROS), Denmark,
The Danish Ministry for Food, Agriculture and Fisheries, Denmark.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

WATERMED
Programme: ATM, project no. 1100066-1, start date 1.2. 2000, cont.
● For this project we use remote sensing to examine water use efficiency in natural vegetation and agricultural areas in the Mediterranean basin. A microscale aggregation model is applied to heterogeneous land surfaces in order to estimate areal heat and water vapour flux on the basis of high-resolution satellite remote sensing data. These results will be compared with field data and low-resolution satellite data results.
Partners: Universitat de València, Spain,
Institut National de la Recherche Agronomique (INRA), France,
Centre Royal de Télédétection Spatial, Morocco,
National Authority for Remote Sensing and Space Sciences (NARSS), Ministry of Higher Education, Egypt.

Sponsor/client: EC, Fifth Framework Programme; Confirming the international role of Community research, INCO-Med.
Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk, tel. +45 4677 5014.

Random Walk Models for the Footprint Problem in the Turbulent Atmosphere
Programme: ATM, project no. 1100068-1, start date 8.6. 2000.
● This project is aimed at the development of new computational stochastic models and measurement techniques for simulating the transport of gases and aerosol particles in the turbulent atmosphere, with specific applications for 'the footprint problem'. 'The footprint problem' concerns the evaluation of concentrations and their fluxes at a specific receptor site, following discharge from various surface and volume sources. The main instruments in this investigation are the stochastic differential equations which – with appropriate approximation – result in random walk algorithms for simulating direct and backward Lagrangian trajectories for parcels of gas flow and aerosol particles. Modelling results are verified and applied to ongoing field measurements of concentrations and fluxes of gases and aerosol particles.
Partners: Department of Physical Sciences, University of Helsinki, Finland,
Russian Academy of Sciences (RAS), Siberian Branch, Russia,
Institute of Atmospheric Physics, RAS, Moscow, Russia,
Weierstrass Institute for Applied Analysis and Stochastics (WIAS), Germany,
University of Bayreuth, Germany,
Physico-Technical Centre 'Climate', Ashgabad, Russia
Sponsor/client: INTAS; International Association for the promotion of cooperation with scientists from the New Independent States of the former Soviet Union, established by the EC.
Contact: Niels Otto Jensen, n.o.jensen@risoe.dk, tel. +45 4677 5007.

ENSEMBLE
Programme: ATM, project no. 1100069-1, start date 1.10. 2000, cont.
● EC's ENSEMBLE project addresses the problem of achieving a common, coherent strategy among European national emergency management agencies, when national long-range dispersion forecasts differ from one another during an accidental atmospheric release of radioactive material. ENSEMBLE produces new, Web-based software tools for real-time reconciliation and harmonisation of dispersion forecasts from meteorological and emergency centres across Europe during an accident. ENSEMBLE software tools will be made available to participating national emergency and meteorological forecasting centres, who may integrate them directly into operational emergency information systems or use them for future systems development.
Partners: German Meteorological Service (DWD), Germany,
Het Koninklijk Nederlands Meteorologisch Instituut (KNMI), Netherlands,
National Institute of Public Health and the Environment (RIWM), Netherlands,
Royal Meteorological Institute of Belgium, Belgium,
Météo-France, France,
Met Office, England
Finnish Meteorological Institute, Finland,
Swedish Meteorological and Hydrological Institute, Sweden,
Danish Meteorological Institute, Denmark,
Central Institute of Meteorology and Geodynamics, Austria,
Enviroware srl, Italy,
Institute of Atomic Energy, Poland,
Norwegian Meteorological Institute, Norway,

National Centre for Scientific Research 'Demokritos', Greece,
Institute for Environment and Sustainability (part of JRC), Ispra, Italy,
University of Manchester, England,
Savannah River Site, U.S. Dept. of Energy, USA,
Danish Emergency Management Agency, Denmark.
Sponsor/client: EC, Directorate-General for Research, Fifth Framework Programme; Research and training in the field of nuclear energy.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

DAONEM
Programme: ATM, project no. 1100070-1, start date 1.10. 2000.
● The objective of DAONEM (Data Assimilation for Off-site Nuclear Emergency Management) is to improve the predictive capabilities of the RODOS system (Real-time On-line Decision Support) by developing and implementing data assimilation tools. In the development of a data assimilation capability for the early phase, the Gaussian puff mesoscale RIMPUFF atmospheric dispersion model will be used. This model provides a realistic description of the various processes associated with atmospheric dispersion of radioactive material, without requiring too much computing time. The model's lack of complexity will prove advantageous, as in more complex models, e.g., a particle model, the implementation of the Kalman filter would be at least an order of magnitude more difficult. The architecture of the original dispersion model will need modifications in order to meet requirements imposed by the data assimilation approach. Almost all work by Risø has been undertaken within the first project year, 1 October 2000 through to 30 September 2001.
Partners: Belgian Nuclear Research Centre (SCK/CEN), Belgium,
University of Warwick, England.
Sponsor/client: European Commission, Fifth Framework Programme; Research and training in the field of nuclear energy.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

Dispersion of Fertilizer from Water Cannons
Programme: ATM, project no. 1100071-1, start date 3.10 2000.
● For the Danish authorities, we have asssessed the risk to human health from aerosols, produced by the use of big irrigation guns for spreading water-diluted manure/slurry. Aerosols may contain pathogenic agents such as bacteria, virus or protozoa, and will – depending on their size and the climatic conditions – drift over greater or smaller distances, thereby posing a risk of airborne infections in humans as well as animals. The potential drift of aerosols rely on a number of factors; most important is the wind movement, but temperature, relative humidity and atmospheric stability are also important. A version of RIMPUFF (Risø Mesoscale Puff Model) including a model for dispersion and evaporation of droplets has been employed to calculate dispersion, and we have studied a number of relevant dispersion scenarios. It is our conclusion that the use of irrigation guns poses a substantial increase in risk to humans and animals, compared to traditional techniques.
Partners: Danish Zoonosis Centre, now department at the Danish Veterinary Institute, DVI, Denmark
Sponsor/client: Danish Zoonosis Centre at DVI, Copenhagen, Denmark
Contact: Søren Thykier-Nielsen, soeren.thykier@risoe.dk, tel. +45 4766 5026.

DSSNET
Programme: ATM, project no. 1100072-1, start date 1.10. 2000, cont.

● DSSNET (Network of Users and Developers of Decision Support Systems for Off-site Emergency Management) will establish an effective and accepted framework for better communication and understanding between the operational community and the many and diverse disciplines involved in R&D in order to make well informed and consistent judgements with respect to practical improvements of emergency response in Europe. DSSNET will establish a close interaction between the users of decision support systems; users of RODOS (Real-time On-line Decision Support) in particular, and the R&D community, in order to improve mutual understanding and encourage feedback on practical experiences from systems application.
Partners: Forschungszentrum Karlsruhe, Germany.
Sponsor/client: European Commission, Fifth Framework Programme; Research and training in the field of nuclear energy.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

EU SAMEN
Programme: ATM, project no. 1100073-1, start date 1.1. 2001.
● The objectives of the SAMEN cluster are
• to ensure the efficient and timely exchange of data, information and results among the respective EC Fifth Framework Programme radiation protection projects, thus avoiding duplication, maximising synergy and promoting coherence,
• to provide a forum that may review and monitor progress within each project and advise on the direction of research in the subsequent period,
• to maintain focus on the broader objectives of the programme area to which the separate projects are subservient,
• to ensure that each project retains a practical focus (i.e. is undertaken in a manner that will facilitate practical effect),
• to provide better feedback between the research and potential user communities, and
• to facilitate and promote the timely use of results/developments in practical decision support systems for off-site emergency management and restoration (particularly in the RODOS system).
Partners: Forschungszentrum Karlsruhe, Germany,
National Radiological Protection Board, United Kingdom,
Belgian Nuclear Research Centre (SCK/CEN), Belgium.
Sponsor/client: European Commission, Fifth Framework Programme; Research and training in the field of nuclear energy.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

SOLA Review
Programme: ATM, project no. 1100074-1, start date 15.1. 2001.
● This project encompasses review series of external persons, institutions or research programmes.
Partners: None
Sponsors: Various – chiefly the European Commission.
Contact: Søren Larsen, soeren.larsen@risoe.dk, tel. +45 4677 5012.

NOJE Review
Programme: ATM, project no. 1100074-2, start date 15.1. 2001.
● This project encompasses review series of external persons, institutions or research programmes.
Partners: None
Sponsors: Various – chiefly the European Commission.
Contact: Niels Otto Jensen, n.o.jensen@risoe.dk, tel. +45 4677 5007.

Modelling, Performance Optimisation for Ultra-High Resolution, Inhomogeneous Conditions
Programme: ATM, project no. 1100075-1, start date 17.1. 2001.
● This is a PhD project regarding the development of a model for atmospheric chemistry transport on a regional scale.
Partners: National Environmental Research Institute (DMU), Denmark.
Sponsors: National Environmental Research Institute (DMU), Denmark,
Danish Research Training Council (formerly Forskerakademiet), Denmark.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

Ar-41 Lidar Experiment
Programme: ATM, project no. 1100077-1, start date 1.1. 2001.
● This is an experimental exercise, the purpose of which is to evaluate the coupled near-range atmospheric dispersion and dose rate module in RIMPUFF (Risø Mesoscale Puff Model), as it is presently used by nuclear emergency decision support systems RODOS and ARGOS NT. Based on the small, but traceable amount of routinely released Argon-41 from the SCK/CEN research reactor in Mol, Belgium, the vent plume's centreline and dispersion parameters are determined experimentally from lidar scans and simultaneously measured ground radiation fluxes. The resulting database will provide experimental validation data for the ongoing development of data assimilation modules for local scale assesssments.
Partners: Nuclear Safety Research and Facilities Department (NUA), Risø National Laboratory, Denmark,
Belgian Nuclear Research Centre (SCK/CEN), Belgium,
Danish Emergency Management Agency, Denmark,
Technical University of Denmark.
Sponsor/client: Nordic Nuclear Safety Research; a Nordic co-operation.
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

3D Extreme Loads
Programme: ATM, project no. 1100078-1, start date 1.3. 2001.
● The objective of this project is to improve the design base for extreme and fatigue loads on wind turbines in flat or mountainous terrain. Main activity is the development of models for non-Gaussian 3-D turbulence fields and extreme gusts or change of direction. We will also gather information on the probability of extreme events and distribution of turbulence probability. For further information, see www.risoe.dk/vea-atu/extreme-fatigue.
Partners: Technical University of Denmark,
NEG Micon A/S, Denmark.
Sponsor/client: Danish Energy Authority, Denmark.
Contact: Morten Nielsen, morten.nielsen@risoe.dk, tel. +45 4677 5022.

Earth Observation Data for Up-scaling Carbon Flux and Water Budget at Zealand (EO-Flux-Budget)
Programme: ATM, project no. 1100079-1, start date 1.1. 2001.
● Measurements of CO_2 emission and deposition on Zealand are collected from five sites representing major Danish biotopes. These measurements provide information on the temporal variability of ecosystem fluxes and their longer-term trends, whereas EO-Flux-Budget combines Earth observation (EO) data and a GIS-based soil/vegetation/atmosphere transfer model (DaisyGIS) for the spatial upscaling of such data from Zealand. Due to the heterogeneous nature of the

landscape, the surface conditions responsible for atmospheric fluxes vary with the scale of modelling. In EO-Flux-Budget, 'effective' (or aggregate) surface variables are computed directly at the scale of interest using multiple-resolution EO data, including vegetation quantity and chlorophyll contents, as they are particularly important when estimating the carbon sinks on Earth. Maps of CO_2 exchange and evapotranspiration rates will be produced and validated in time and space, using tower fluxes and airborne flux measurements.
Partners: Institute of Geography, University of Copenhagen, Denmark, (co-ordinator),
Plant Research Department, Risø National Laboratory, Denmark,
DHI Water & Environment, Denmark,
Royal Veterinary and Agricultural University, Denmark.
Sponsor/client: Danish Research Agency, Denmark,
Follow-up to European Space Agency (ESA) project.
Contact: Charlotte B. Hasager, charlotte.hasager@risoe.dk, tel. +45 4677 5014.

Investigation of Lagrangian Properties of Turbulence
Programme: ATM, project no. 1100081-1, start date 22.6. 2001.
● New techniques are used to measure all terms in the Navier-Stokes equations; only exception is the pressure gradient, which can be calculated from other terms. This requires measurements of velocity gradients and acceleration on scales of the order of the Kolmogorov scale, which may be achieved with three-dimensional particle tracking by four digital cameras. Using an ultra-fast position sensitive diode and a sweeping laser sheet would be another relevant option. The latter part of the project concentrates on measuring the movements of groups of particles.
Partners: None
Sponsor/client: Danish Research Agency.
Contact: Jakob Mann, jakob.mann@risoe.dk, tel. +45 4677 5019.

Investigation of a New Bi-static SODAR Remote Sensing Concept for Wind Profile Measurements in Connection with Large Wind Turbines
Programme: ATM, project no. 1100082-1, start date 1.8. 2001.
● This project relates to the new generation of big wind turbines; by means of sound, we investigate ground-based remote sensing of the vertical wind speed profile. At high wind speeds and during near-neutral stratifications, a bi-static SODAR (Sonic Detection and Ranging) configuration possesses inherent advantages over the traditional mono-static configurations. This project investigates the theoretical potentials in bi-static acoustic SODAR systems for better accuracy with remote sensing of vertical wind profiles. A pilot bi-static SODAR instrument will be developed and tested for performance during various meteorological conditions and inter-compared with the 123 metres tall meteorological tower at Risø. The bi-static SODAR concept is being investigated with a view to replacing met tower-based wind profile measurements at heights between 50 and 150 m.
Partners: None.
Sponsor/client: Danish Research Agency
Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk, tel. +45 4677 5009.

Electrical Design and Control, EDS

Research programme
Head; Peter Hauge Madsen

The purpose of this programme is to contribute new knowledge and computational models for the analysis and development of wind turbines with regard to electric and control characteristics as well as grid and systems integration. In co-operation with Aalborg University we will obtain these goals through a long-term strategic and applied research and development effort directed towards control principles for the operation and application of wind turbines, their electromechanical components and integration into power systems.
Mid-term goals are
- to develop new control concepts for the optimization of wind turbine loads, production and power quality,
- to assess and test potential applications of alternative electromechanical components for wind turbines including new advanced generators and power electronics, and
- to develop methods and concepts for the electrical integration of large shares of renewable energy, wind energy in particular, into centralized and decentralized energy systems.

EDS projects

Simulation of Wind Power Plants

Programme: EDS, project no. 1115018-00, start date 1.4. 2000, cont.
- The objective of this project is to develop models for the simulation of wind farms and their interaction with the grid. This is a first step in support of the development of large wind farms that can contribute to the regulation and stabilisation of the grid, thus enabling wind farms to replace other power plants in the future. A model for the 6×2 MW wind farm in Hagesholm has been developed with DIgSILENT, a commercial tool for power system simulation. This model has been verified for stationary conditions considering the influence of turbulence, and it has been demonstrated that the model is capable of predicting a number of power quality characteristics defined in the IEC 61400-21 standard for measurement and assessment of power quality of grid connected wind turbines.

Partners: Aalborg University, Denmark,
DanControl Engineering A/S, Denmark,
Sponsor/client: Danish Energy Authority, EFP 2000.
Contact: Poul Sørensen, poul.soerensen@risoe.dk, tel. +45 4677 5075.

Condition Monitoring of Wind Turbine

Programme: EDS, project no. 1115019-00, start date 4.4. 2000, cont.
- The objective of this project is to further develop the condition monitoring system of modern wind turbines in order to reduce down time and maintenance costs. This means improved methods for monitoring loads and rotor operating conditions as well as generator/bearings/gearbox operating conditions and state of health in order to avoid operation in damaging conditions and to reduce or stop production before serious failure of main components.

Partners: Vestas Wind Systems A/S, Denmark,
Institute of Energy Technology, Aalborg University, Denmark.
Sponsor/client: Danish Energy Authority, EFP 2000.
Contact: Henrik Bindner, henrik.bindner@risoe.dk, tel. +45 4677 5050.

Wind Plus
Programme: EDS, project no. 1115020-00, start date 4.4. 2000, cont.
● This project is concerned with the development of operating and control strategies for storage systems in wind/diesel power systems. The key objective is to develop control strategies for energy storage systems based on lead-acid batteries in order to obtain long battery lifetime, save fuel and improve system power quality. This includes the development of power electronics, development and implementation of control strategies and testing technology in real-life power systems.
Partners: Vergnet SA, France,
Energy research Centre of the Netherlands (ECN), Netherlands,
Asea Brown Boveri Ltd. (ABB), Switzerland,
CINAR, Greece,
SgurrEnergy, United Kingdom.
Sponsor/client: EU.
Contact: Henrik Bindner, henrik.bindner@risoe.dk, tel. +45 4677 5050.

Research and Development
Programme: EDS, project no. 1115021-01, start date 7.7. 2000, cont.
● Research and development activities within the EDS programme that are not directly related to any individual project. Includes our collaboration with Aalborg University.
Partners: Aalborg University.
Sponsor/client: None.
Contact person: Peter Hauge Madsen, peter.hauge@risoe.dk, tel. +45 4677 5011.

Gaia Wind Turbine for use in Wind/Diesel Systems and as Stand-alone
Programme: EDS, project no. 1115022-1, start date 18.1. 2001.
● The 11 kW Gaia wind turbine will be modified so as to operate in a wind/diesel system, and the operation subsequently documented by measurements. Another major part of the project involves further development of the wind turbine, thus enabling it to operate without other generating units such as a diesel generator. The stand-alone version of the wind turbine will also be tested and its performance documented.
Partners: Gaia Wind A/S, Denmark,
Mita-Teknik A/S, Denmark,
Aalborg University, Denmark.
Sponsor/client: Danish Energy Authority, UVE (development programme for renewable energy).
Contact: Henrik Bindner, henrik.bindner@risoe.dk, tel. +45 4677 5050.

Integration VEA/SYS
Programme: EDS, project no. 1115023-00, start date: 1.1. 2001.
● This project was initiated in order to identify required research tasks regarding the integration of renewable energy, in order to obtain a cost-effective energy system with a very large proportion of renewable energy. This will be based on a state-of-the-art report with particular attention to the potential utilization of Risø's variety of expertise in this field.

Partners: Systems Analysis Department and Materials Research Department, both Risø National Laboratory, Denmark.
Sponsor/client: None.
Contact: Henrik Bindner, henrik.bindner@risoe.dk, tel. +45 4677 5050.

Simulation and Verification of Transient Events in Large Wind Power Installations
Programme: EDS, project no. 1115024-1, start date 1.7. 2000, cont.
● The objective of this project is to assess the ability of various dedicated power system simulation tools to predict the response of wind farms to transient events such as grid faults in the power system. The Danish transmission system operators has made the simulation of this response a prerequisite for the connection of major (offshore) wind farms directly to the transmission system. In a case study we use models for the 6×2 MW wind farm in Hagesholm. The models were developed by means of power system simulation tools DIgSILENT and EMTDC.
Partners: North-West Zealand Energy Supply Company (NVE), Denmark,
Aalborg University, Denmark,
DanControl Engineering A/S, Denmark.
Sponsor/client: Elkraft System a.m.b.a., Denmark.
Contact: Poul Sørensen, poul.soerensen@risoe.dk, tel. +45 4677 5075.

Investire
Programme: EDS, project no. 1115027-00, start date 8.6. 2000, cont.
● The main objectives of the Investire network (Investigations on Storage Technologies for Intermittent Renewable Energies) are to review and assess present-day storage technologies in the context of renewable energy applications, to facilitate the exchange of information among the main actors and to propose appropriate research and technological development (RTD) for the future. In detail, this includes
• the review of possible storage technologies that are suited to renewable energy systems,
• identification of research priorities and the publication of a long-term RTD roadmap,
• encouraging the formation of new RTD partnerships, and
• fostering cooperation between battery manufacturers and designers/suppliers of renewable energies systems.
Partners: Renewable Energies Group of the Establishment of Cadarache (GENEC), French Atomic Energy Commission (CEA), France, co-ordinator, and 34 partners from Europe and outside.
Sponsor/client: EC, D-G for Research, Fifth Framework Programme.
Contact: Per Lundsager, per.lundsager@risoe.dk, tel. +45 4677 5045.

PSO Green Power Converter
Programme: EDS, project no. 1115028-1, start date August 2001.
● The purpose of this project is to develop new and cost-effective power converters for the connection of photovoltaic (pv) panels to the grid. In particular we will emphasize low cost, high reliability and suitability for mass production. The tasks include
• specification, modelling and simulation of new converter topologies,
• selection of best topology, and
• laboratory as well as field testing.
Partners: Aalborg University, Denmark,
Danish Technological Institute (TI), Denmark,
Danfoss A/S, Denmark.
Sponsor/client: Elkraft System a.m.b.a., Denmark.

Contact: Henrik Bindner, henrik.bindner@risoe.dk, tel. +45 4677 5050.

Benchmarking
Programme: EDS, project no. 1115029-00, start date 2.1. 2002, cont.
● This project concerns the development of test procedures for benchmarking of energy storage systems and related components. Results will enable users to select the optimum energy storage product for their specific application. They may also be used by manufacturers to clearly define the category of RES (renewable energy system) to which their product is best suited and to estimate the expected lifetime for a well-defined category of use. Working in close contact with the International Electrotechnical Commission (IEC) and their relevant committees, this project will provide a framework for defining detailed technical standards, appropriate for a maturing industry. This framework should be technology-neutral so as not to to exclude any future technologies or applications of RES.
Partners: Fraunhofer Institute for Solar Energy Systems (ISE), Germany, co-ordinator,
and 10 European contractors (including Risø National Laboratory),
National Renewable Energy Laboratory (NREL), US Dept. of Energy, USA.
Sponsor/client: EC, D-G for Research, Fifth Framework Programme.
Contact: Per Lundsager, per.lundsager@risoe.dk, tel. +45 4677 5045.

Wind Power Meteorology, VKM

Research programme
Head; Lars Landberg

The objective of this programme is to contribute new knowledge of wind climatology, atmospheric flow and turbulence as a basis for the development and application of methods and models that are capable of predicting wind resources as well as wind loads on wind turbines and other structures in all kinds of natural terrain.
This is a long-term research effort in wind climatology and atmospheric flow on meso- and microscale. Mid-term goals are
– to further develop models and to extend the geographic scope of the wind atlas method for wind resource studies.
– to further develop models for a short-term prediction of wind farm production.
– to develop and combine the wind atlas method with models for atmospheric turbulence and extreme events with regard to wind load calculations in order to estimate extreme wind conditions in natural terrain.
– to develop models for offshore wind flow including resources and extreme wind loads and to suppport these models by measurements.

VKM projects

Wind Energy Assessment and Wind Engineering (WINDENG)
Programme: VKM, project no. 1105065-1, start date 1.9. 2002.
● Risø is the co-ordinator of this project, concerning a European training network under the auspices of EU's Fifth Framework Programme; Improving human research potential. The purpose of the network is to bring together young and experienced researchers to work jointly on defining the basis for the design of wind turbines and wind farms in different environments.
This includes;
• The definition of reliable values for turbulence descriptors to be used in the modelling of turbulent wind fields (i.e. turbulence intensity, spectra, coherence, shear etc.) in homogeneous, complex terrain and offshore. These values and descriptors will be included in guidelines for wind turbine design.
• Improvement of present-day methods for modelling wind climates throughout Europe in order to provide reliable tools for calculating energy production from wind farms in complex terrain and offshore.
The network will address all European climates from the cold Scandinavian to the Mediterranean regions. We will also offer guidelines for optimum turbine design and siting procedures for isolated generators or turbine parks. Young scientists will participate in national and international research programmes and research strategies. The exchange of experience and personal contacts among the academic and research institutions and private companies involved will result in improved design criteria for end-users.
Partners: Risø National Laboratory (co-ordinator), Denmark,
University of Oldenburg, Germany,
German Wind Energy Insititute, (DEWI), Germany.
NEG Micon, Denmark.

Centre for Renewable Energy Sources, CRES, Greece,
SEAS, Denmark,
Istituto di Fisica dell'Atmosfera, (IFA), Italy.
Finnish Meteorological Institute (FMI), Finland.
Sponsor/client: European Commission, Fifth Framework Programme.
Contact: Anna Maria Sempreviva, anna.sempreviva@risoe.dk, tel. +45 4677 5025, Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

The Numerical Wind Atlas
Programme: VKM project no. 105026-09 start date 1.1.2002.
● Development and application of the numerical wind atlas method. The method combines the Karlsruhe Atmospheric Mesoscale Model (KAMM) with Risø's WAsP (Wind Atlas Analysis and Application Program) in order to model the wind resource at any given location. Web-site: www.mesoscale.dk.
Partners: Various.
Sponsor/client: Various.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

European Wind Atlas
Programme: VKM, project no. 1105001-00, start date 1.1. 1989, cont.
● Distribution of the European Wind Atlas, published in 1989.
Partners: None.
Sponsor/client: Various.
Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk, tel. +45 4677 5027.

Wind Atlas Analysis and Application Program (WAsP)
Programme: VKM, project no. 1105002-01/02, start date 1.7. 1987, cont.
● WasP encompasses the development, implementation and verification of software tools for;
• wind data analysis,
• map editing and digitisation,
• wind atlas generation,
• wind climate estimation,
• prediction of wind power production,
• micro-siting of wind turbines,
• wind farm production calculations,
• wind farm efficiency evaluation, as well as
• wind climate and wind resource mapping.
This project also includes software support, courses and training.
Partners: None.
Sponsor/client: Various
Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk, tel. +45 4677 5027.

Wind Atlas for the Gulf of Suez
Programme: VKM, project no. 1105005-00, start date 1.1. 1995, cont.
● Distribution of Wind Atlas for the Gulf of Suez 1991-95 and the associated database.
Partners: None
Sponsor/client: Various
Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk, tel. +45 4677 5027.

Wind Atlas for Russia
Programme: VKM, project no. 1105007-00, start date 20.11 1997, cont.
● This project concerns the development of a wind atlas for Russia, using the Risø Wind Atlas Methodology. We will analyse data from more than 300 stations distributed all over the Russian territory. Each station will be analysed with respect to meteorological data (wind speed and direction), terrain (orography and roughness) and obstacles.
Partners: The Russian-Danish Institute for Energy Efficiency (RDIEE), Moscow, Russia.
Sponsor/client: Danish Energy Authority.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

Instrumentation of Offshore Masts
Programme: VKM, project no. 1105011-00, start date 1.8. 1997, cont.
● Two major Danish power supply companies, SEAS and Elkraft, have sponsored our instrumentation of a number of offshore masts (Gedser Land, Gedser Rev, Rødsand and Omø Stålgrunde) as well as running of the meteorological instrumentation necessary in order to provide a database for wind resource assessment.
Partners: None.
Sponsor/client: SEAS, Denmark,
Elkraft, Denmark.
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

WAsP Consulting
Programme: VKM, project no. 1105026-01, start date 20.11. 1997, cont.
● An important VKM activity is consulting in connection with wind resource estimation. This may include second opinion studies, due diligence, offshore wind farm production estimation and measuring programmes.
Partners: Various commercial and international institutions.
Sponsor/client: Various.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

Predicting Offshore Wind Energy Resources (POWER)
Programme: VKM, project no. 1105036-1, start date 1.8. 1998, cont.
● So far, the focus of this project has been on the mapping of thirteen years of near-surface offshore wind speeds throughout the European Union. The wind speeds are based on pressure gradients (geostrophic wind). The WAsP model is compared to a newly developed Coastal Discontinuity Model (CDM) which accounts for stability variations in coastal regions by means of temperature differences. Results indicate that stability is a very important factor in predicting wind profiles at a distance of up to 20 km from the coast. Initial comparisons with SODAR data (collected by Ecofys at the measurement platform Noordvik) also indicate substantial variations from the classic 'log-profile' even during the winter period.
Partners: CCLRC, Rutherford Appleton Laboratory, England,
Ecofys, Netherlands,
KEMA Power Generation & Sustainables, Netherlands,
University of East Anglia, England.
Sponsor/client: European Commission, the JOULE programme
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

EFP99, Zephyr
Programme: VKM, project no. 1105039-1, start date 1.4. 1999, cont.
● This project concerns the development of a new system (Zephyr) for short-term prediction of output from wind farms. Zephyr combines Risø's physical approach with the statistical approach of IMM at the Technical University of Denmark and the system is to be implemented at all Danish utilities using wind energy. Predictions will be derived from the HIRLAM model of the Danish Meteorological Institute.
Partners: Technical University of Denmark, dept. of Informatics and Mathematical Modelling (IMM), Denmark,
Danish Meteorological Institute, Denmark,
SEAS, Denmark,
Elkraft, Denmark,
Elsam A/S, Denmark,
Eltra, Denmark.
Sponsor/client: Danish Energy Authority, EFP 1999 energy research programme.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

Transfer of Wind Resource Know-How to the Czech Republic
Programme: VKM, project no. 1105042-1, start date 1.11. 1999, cont.
● The purpose of this project is to increase the capacity in the Czech Republic to estimate domestic wind resources. A training workshop for about 10 target persons has been established. The project also provides a survey of wind resources in the Czech Republic, clarifying and possibly seeking to propose a solution for a presently less successful wind farm project.
Partners: None.
Sponsor/client: The former Danish Co-Operation for Environment and Development (DANCED), now Danida, Danish Foreign Office.
Contact: Ole Rathmann, ole.rathmann@risoe.dk, tel. +45 4677 5003.

EPRI-Prediktor Texas
Programme: VKM, project no. 1105043-1, start date 1.10. 2000, cont.
● Confidential.
Partners: Confidential.
Sponsor/client: Electric Power Research Institute (EPRI), California, USA,
Dept. of Energy (DOE), USA.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

Efficient Development of Offshore Wind Farms (ENDOW)
Programme: VKM, project no. 1105044-1, start date 1.3. 2000, cont.
● ENDOW is a new research project, co-ordinated at Risø and funded by the European Commission's Fifth Framework Programme. The objectives of the project are to evaluate the performance of a variety of wake models in the offshore environment, to enhance these models and link them to improved boundary layer models. This will enable a comparison of offshore wake effects to other factors which have an impact on the design and economics of offshore wind farms.
Partners: Uppsala University, Sweden,
Garrad Hassan and Partners Ltd, England,
The Robert Gordon University, United Kingdom,
University of Oldenburg, Germany,
SEAS, Denmark,

Elsam A/S, Denmark,
NEG Micon A/S, Denmark,
Energy research Centre of the Netherlands (ECN), Netherlands,
Ecofys (subcontractor to ECN), Netherlands.
Sponsor/client: European Commission, Fifth Framework Programme.
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

Baltic Wind Atlas
Programme: VKM, project no. 1105045-1, start date 1.1. 2000, cont.
● The aim of this project is to establish a wind atlas for relevant areas in the Baltic countries by reviewing and analysing wind measurements already existent and by establishing new measurements in particularly promising (coastal) areas. Our contribution is mainly consultancy on the selection of new measurement sites as well as the purchase and installation of measuring equipment.
Partners: UNDP, Global Environment Facility (GEF), project co-ordinator),
Lars Mach, free-lance consultant, Germany.
Sponsor/client: United Nations Development Programme (UNDP),
United Nations Office for Project Services (UNOPS).
Contact: Ole Rathmann, ole.rathmann@risoe.dk, tel. +45 4677 5003.

Prediktor
Programme: VKM, project no. 1105046-1, start date 1.10. 2000, cont.
● Sales, marketing and implementation of the Prediktor short-term prediction system
Partners: Various
Sponsor/client: Various
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

EPRI Prediktor California
Programme: VKM, project no. 1105047-1, start date 1.10. 2000, cont.
● Confidential.
Partners: Confidential.
Sponsor/client: Electric Power Research Institute (EPRI), California, USA,
California Energy Commission, USA.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

UNEP/ SWERA Global Wind Atlas
Programme: VKM, project no. 1105048-1, start date 2.3. 2000, cont.
● This project concerns the development of a full-scale project, the purpose of which is to create a solar and wind atlas for 10-15 countries around the globe; SWERA, Solar and Wind Energy Resource Atlas. The output of current work will be a proposal to UNEP for this full-scale project.
Partners: National Renewable Energy Laboratory (NREL), USA,
The Energy and Resources Institute (TERI), (formerly Tata Energy Research Institute), India.
Sponsor/client: United Nations Environmental Programme (UNEP), Global Environment Facility (GEF),
Risø National Laboratory, VKM.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

WAsP Engineering 2000

Programme: VKM, project no. 1105049-1, start date 1.3. 2000, cont.
● The purpose of this project is to verify, refine and develop micrometeorological tools for the estimation of load-critical wind conditions in Danish and other European landscapes where wind turbines are likely to be erected. These conditions include turbulence – natural as well as turbine wake generated turbulence – shear, and extreme winds. Other objectives are;
• to establish connections between measured storms in Denmark and a global meteorological database,
• to develop computer implementations of turbine wake models,
• to construct an extreme value analysis module of meteorological records,
• and to investigate the limitations of the models' applicability.
Partners: Svend Ole Hansen ApS, Denmark,
Vestas Wind Systems A/S, Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Jakob Mann, jakob.mann@risoe.dk, tel. +45 4677 5019.

CDMed
Programme: VKM, project no. 1105050-1, start date 1.3. 2000, cont.
● Scenarios and strategies for the implementation of the Kyoto Protocol's Clean Development Mechanism in the Mediterranean region.
Partners: Observatoire Mediterraneen de L'energie (OME), co-ordinator, France,
EC's Joint Research Centre; Institute for Prospective Technological Studies (IPTS), Spain,
Enel, Italy,
New and Renewable Energy Authority (NREA), Egypt.
Sponsor/client: EC, Directorate-General for Research.
Contact: Erik Lundtang Petersen, erik.lundtang@risoe.dk, tel. +45 4677 5001.

CleverFarm
Programme: VKM, project no. 1105051-1, start date 1.4. 2000, cont.
● The objective of this project is to construct an 'intelligent' computer system, which integrates a broad variety of monitoring approaches. The system includes short-term prediction of the wind farm's electricity production, video camera surveillance as well as information on current running conditions and prediction of wind turbine fault. This combination enables the owner to effectively plan the maintenance of the wind farm. Furthermore, short-term predictions add extra value by optimizing trading on wind farm produced electricity.
Partners: Gram & Juhl, Denmark,
Danish Meteorological Institute, Denmark,
Institut für Solare Energieversorgungstechnik (ISET), Germany,
Renewable Energy Systems Ltd. (RES), United Kingdom,
SEAS, Denmark,
University of Oldenburg, Dept. of Energy and Semiconductor Research (EHF), Germany.
Sponsor/client: EC, Fifth Framework Programme; Energy, environment and sustainable development.
Contact: Gregor Giebel, gregor.giebel@risoe.dk, tel. +45 4677 5095.

WEMSAR
Programme: VKM, project no. 1105052-1, start date 1.3. 2000, cont.
● Wind energy mapping (WEM) using synthetic aperture radar (SAR). We will develop, validate and demonstrate the potential use of satellite-based SAR, scatterometer and altimeter data combined

with meteorological observations for the mapping of wind resources in offshore and near-coastal regions. The sites in question are located in Norway, Denmark and Italy. For regional scale calculations the Karlsruhe Atmospheric Mesoscale Model (KAMM) will be used, whereas WasP will be used for local scale calculations.
Partners: Nansen Environmental and Remote Sensing Center, Norway,
NEG Micon A/S, Denmark,
Terra Orbit AS, Norway,
Italian National Agency for New Technologies, Energy and the Environment (ENEA), Italy.
Sponsor/client: EC, Fifth Framework Programme; Energy, environment and sustainable development.
Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk, tel. +45 4677 5014.

Improved Description of the Wind Climate in Denmark Regarding Determination of the Wind Resource
Programme: VKM, project no. 1105053-1, start date 4.1. 2000, cont.
- The Danish Meteorological Institute is developing HIRLAM (HIgh Resolution Limited Area Model) further in order to improve the prediction of wind and weather in general. One objective is to investigate the possibility of using the electricity production of wind turbines as a measure of wind speed, i.e. to use the wind turbines in a fashion similar to huge anemometers. We use the wind farm model in WasP to derive wind speed information from power generation. The electric transmission utility company Eltra provides power data.

Partners: Danish Meteorological Institute (DMI), Denmark,
Eltra, Denmark,
Sponsor/client: Danish Energy Authority, EFP 2000 (energy research programme).
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

UVE-2000, Calculation of Energy Production
Programme: VKM, project no. 1105054-1, start date 1.1. 2000, cont.
- Establishment of a database of case studies containing data and information required to evaluate the accuracy and reliability of wind power production estimations using different approaches and computer models. Case studies are established for different wind climatologies and topographical settings. Comparison of predictions and actual power productions from wind turbines and wind farms serve to evaluate and map the uncertainties involved and, possibly, improve prediction skills.

Partners: Energy and Environmental Data, Denmark,
Elsamprojekt, Denmark,
WEA Engineering, Denmark,
Bonus Energy A/S, Denmark,
NEG Micon A/S, Denmark,
Nordex, Denmark,
Vestas Wind Systems A/S, Denmark,
Wincon, Denmark.
Sponsor/client: Danish Energy Authority, UVE (development programme for renewable energy),
WEA Engineering, Denmark,
Bonus Energy A/S, Denmark,
NEG Micon A/S, Denmark,
Nordex, Denmark,
Vestas Wind Systems A/S, Denmark,
Wincon, Denmark.
Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk, tel. +45 4677 50 27.

SNF-WINDENG
Programme: VKM, project no. 1105055-1, start date 25.5. 2000, cont.
● This concerns the writing of a proposal to the European Commission for a research network in wind power meteorology-related subjects.
Partners: None.
Sponsor/client: The Danish Natural Science Research Council (SNF), Denmark.
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

Wind Atlas for South Africa
Programme: VKM, project no. 1105056-1, start date 6.6. 2000, cont.
● Consultancy to Eskom (South Africa's state-owned national electricity utility) on how to establish a wind atlas for South Africa. This includes conducting a WAsP course in South Africa as well as assisting with the analysis and quality control of the wind atlas.
Partners: None.
Sponsor/client: Eskom, South Africa.
Contact: Ole Rathmann, ole.rathmann@risoe.dk, tel. +45 4677 5003.

RB Consulting
Programme: VKM, project no. 1105057-1, start date 1.5. 2000.
● Consulting in relation to offshore wind energy development.
Partners: None.
Sponsor/client: Various commercial companies.
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

UVE, The New WAsP
Programme: VKM, project no. 1105058-1, start date 1.4. 2000.
● The purpose of the project is to develop the next generation flow model in relation to WasP; Wind Atlas Analysis & Application Program.
Partners: Energy and Environmental Data, Denmark.
Sponsor/client: Danish Energy Authority; UVE (development programme for renewable energy).
Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

EU MED 2010
Programme: VKM, project no. 1105059-1, start date 9.1. 2001.
● Large-scale integration of solar and wind power in Mediterranean countries.
Partners: Observatoire Méditerranéen de l'Energie (OME), France (co-ordinator),
Endesa Cogeneration and Renewables, Spain,
BP Solar, Spain,
Research Centre for Energy, Environment and Technology (CIEMAT), Spain,
Electricité de France (EDF), France,
ARMINES and Ecoles des Mines de Paris, France,
CESI, Italy,
Renewable Energies Development Center (CDER), Morocco,
Société Tunisienne de l'Electricité et du Gaz (STEG), Tunisia,
New and Renewable Enegy Authority (NREA), Egypt,
Electrical Power Resources Survey and Development Administration (EIE), Turkey.

Sponsor/client: EC, Fifth Framework Programme; Energy, environment and sustainable development.
Contact: Erik Lundtang Petersen, erik.lundtang@risoe.dk, tel. +45 4677 5001.

Prediktor in Ireland
Programme: VKM, project no. 1105060-1, start date 6.2. 2001.
- Confidential.

Contact: Lars Landberg, lars.landberg@risoe.dk, tel. +45 4677 5024.

SEAS Offshore Mast Analysis
Programme: VKM, project no. 1105064-1, start date 1.10. 2001.
- Analysis of wind resources at Rødsand, Omø Stålgrunde and Gedser based on measurements from in situ masts from 1996.

Partners: None.
Sponsor/client: SEAS.
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk, tel. +45 4677 5020.

Wind Turbines, VIM

Research programme
Head; Peter Hjuler Jensen

The purpose of this research programme is to develop current methods for wind turbine loading and safety design, new design methods for structural design and to identify new technical and economic applications.
Mid-term goals are
● Loading and safety; establishing a rational and empirical basis for a reliable and economic design of wind turbines with models based on a probability theory.
● Structural design; the development of more fundamental structural design modelling of e.g. wind turbine blades and optimal structural design of wind turbine components, including new test methods for blades.
● Wind power implementation; the development of methods for verification of technical as well as economic risks in wind turbines.

VIM projects

Consulting

Programme: VIM, project no. 1120006, start date 19.11. 1997, cont.
● The VIM programme renders consultancy services to wind turbine manufacturers and power systems operators.
Partners: None.
Sponsor/client: Various.
Contact: Sten Frandsen, sten.frandsen@risoe.dk, tel. +45 4677 5072.

Response Simulations for Offshore Wind Turbines

Programme: VIM and AED, project no. 1120006-13, start date 12.1. 2002, end date 31.1. 2003.
● This project is confidential.
Partners: None.
Sponsor/client: Confidential.
Contact: Niels Jacob Tarp-Johansen, niels.jacob.tarp-johansen@risoe.dk, tel. +45 4677 5078.

Operation and Maintenance Economics of Wind Turbines

Programme: VIM, project no. 1120105-00, start date 1.1. 1998, end 1.4. 2002.
● The purpose of this project is
• to update data and statistics regarding the establishment, operation and maintenance costs of wind turbines, the 500 - 750 kW generation in particular,
• to highlight questions regarding technical and economic lifetime of wind turbines by using the data on operation and maintenance costs,
• to disseminate results in Denmark as well as internationally.
Partners: Danish Wind Industry Association, Denmark,
Elsam, Denmark,
Elkraft, Denmark,
the Danish wind turbine owners' association (Danmarks Vindmølleforening), Denmark,

Sponsor/client: Danish Energy Authority.
Contact: Peter Hjuler Jensen, peter.hjuler@risoe.dk, tel. 045 4677 5037.

Guidelines for Design of Wind Turbines
Programme: VIM, project no. 1120110-00, start date 1.1. 1999, end 1.4. 2002.
● This project was initiated in order to collect and compile the knowledge of wind turbine design accumulated within the last couple of decades, and present it in a clear and easily accessible publication. The publication is produced in a co-operation between Risø National Laboratory and Det Norske Veritas, both parties being engaged in the certification of wind turbines. An outline of current design requirements to be met by new turbines in order to obtain type approval, plays an important part in the guidelines.
Partners: Det Norske Veritas (DNV), Norway.
Sponsor/client: Danish Energy Authority.
Contact: Jesper H. Schaarup, jesper.schaarup@risoe.dk, tel. +45 4677 5065.

Type Approval of Domestic Wind Turbines 2000
Programme: VIM, project no. 1120112-00, start date 1.1. 2000, cont.
● This programme renders commercial type approval (HC and HB approval) according to 'Technical basis for approval of wind turbines with rotor diameter between 2 and 13 metres', and HB type approval of Calorius type 37 version 3.
Partners: None.
Sponsor/client: Wind turbine manufacturers.
Contact: Poul Højholdt, poul.hoejholdt@risoe.dk, tel. +45 4677 5063.

Availability of Offshore Wind Farms
Programme: VIM, project no. 1120117-00, end 2002.
● The purpose of this project is to analyse the availability of offshore wind farms considering the difficulties associated with maintenance. The availability of turbines in view of environmental conditions such as wind, waves, temperature, etc. is analysed. The project seeks to include preventive and corrective maintenance as well as accessibility to personnel.
Partners: Systems Analysis Department, Risø National Laboratory, Denmark,
SEAS Wind Energy Centre, Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Thomas Krogh, thomas.krogh@risoe.dk, tel. +45 4677 5062.

Certification of Wind Turbines
Programme: VIM, project no. 1120120-00, start date 16.1. 2000, cont.
● Det Norske Veritas (DNV) co-operates with Risø in the certification of wind turbines. This co-operation covers all the relevant technological aspects of design verification of wind turbines.
Partners: Det Norske Veritas (DNV), Denmark
Sponsor/client: Wind turbine manufacturers.
Contact: Erik R. Jørgensen, erik.e.joergensen@risoe.dk, tel. +45 4677 5064.

Consultancy to Danish Energy Authority
Programme: VIM, project no. 1120122-00, start date 28.2. 2000, cont.
● The VIM programme renders assistance to the Danish Energy Authority in formulating the strategy and action plan for research and development from 2000 to 2004. This also includes the

evaluation of individual applications for R&D funding under the wind energy research programmes EFP and UVE.
Partners: Danish Energy Authority.
Sponsor/client: Danish Energy Authority.
Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk, tel. +45 4677 5086.

Fatigue Strength and Life of Wind Turbine Components
Programme: VIM, project no. 1120124-00, start date 1.5. 2000, end 31.12. 2002.
● The aim of this project is to develop probabilistic tools for the assessment of fatigue strength and service lifetime of large wind turbine components. Such tools will facilitate the evaluation of uncertainties related to computations of service lifetimes; computations that are indispensable when estimating the economic risk associated with offshore wind turbines.
Partners: Elsam Engineering A/S, Denmark,
a number of Danish wind turbine manufacturers, Denmark,
Materials Research Department, Risø National Laboratory, Denmark.
Sponsor/client: Eltra, Denmark.
Contact: C.P. Debel, c.p.debel@risoe.dk, tel. +45 4677 5061 or
Niels Jacob Tarp-Johansen (VIM), niels.jacob.tarp-johansen@risoe.dk, tel. +45 4677 5078.

Environmentally Sound Design and Recycling of Wind Turbines
Programme: VIM, project no. 1120127-00, start date 20.12. 2000, end 31.12 2002.
● The objective of this project is to develop methodologies for assessment studies of the life cycle of future wind turbines. This includes the use of methods for technology forecast.
Partners: Systems Analysis Department, Risø National Laboratory, Denmark.
Sponsor/client: Danish Energy Authority.
Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk, tel. +45 4677 5086.

Recommendations for Design of Offshore Wind Turbines (RECOFF)
Programme: VIM, project no. 1120129-00, start date 24.1. 2001, end 2004.
● The objective of this project is to prepare guidelines and recommendations for the design of offshore wind turbines. These guidelines and recommendations are to serve primarily as a basis for further development of European and national standards and certification requirements for offshore wind turbines. The project also aims to undertake the preparatory work required for establishing a design standard. Current knowledge will be reviewed and supplied with new applied research where necessary. Results may be used directly by manufacturers and consultants in the design process, and they may influence the contents of future tenders for offshore wind energy projects. The RECOFF project relates to the Danish project 'Combination of external loads'.
Partners: Garrad Hassan & Partners Ltd, England,
Germanischer Lloyd AG, Germany,
Energy research Centre of the Netherlands, Netherlands,
Centre for Renewable Energy Sources (CRES), Greece.
Sponsor/client: EU.
Contact: Sten Frandsen, sten.frandsen@risoe.dk, tel. +45 4677 5072.

Improved Design Rules for Large Wind Turbine Blades
Programme: VIM, project no. 1120130-00, start date 13.3. 2001, end 28.2. 2003.
● On the basis of materials research and development, structural analysis and a series of experiments, we aim to establish more rational design methods for large wind turbine blades.

Partners: Materials Research Department, Risø National Laboratory, Denmark,
Technical University of Denmark,
Aalborg University, Denmark,
LM Glasfiber A/S, Denmark,
Vestas Wind Systems A/S, Denmark.
Sponsor/client: Danish Energy Authority, EFP (energy research programme).
Contact: Christian Debel, christian.debel@risoe.dk, tel. +45 4677 5061.

Optimised and Uniform Safety and Reliability of Offshore Wind Turbines (an Account)
Programme: VIM, project no. 1120132-00, start date 29.5.2001, end 1.7. 2003.
● The purpose of this project is to make a survey of how the overall safety of wind turbines against structural failure depends on the turbines' structural safety as well as the reliability of their control and safety systems.
Partners: Systems Analysis Department, Risø National Laboratory, Denmark,
Det Norske Veritas (DNV), Norway,
Energy research Centre of the Netherlands (ECN), Netherlands,
Aalborg University, Denmark.
Sponsor/client: Elkraft, Denmark.
Contact: Niels Jacob Tarp-Johansen, niels.jacob.tarp-johansen@risoe.dk, tel. +45 4677 5078.

Combination of External Loads on Wind Turbine Structures
Programme: VIM, project no. 1120133-00, start date 21.6. 2001, end 30.6. 2003.
● With the growing size of offshore projects, wave and ice loads become increasingly important as compared to wind loads. Thus, the optimal design of offshore turbines relies heavily on optimal design regulations, i.e. on a minute specification of the combined external loads. This project deals with the surveying of environmental loads on offshore turbines situated in the Danish seas. We particularly emphasize the concerted action of loads and safety levels. This project complements the European RECOFF project.
Partners: SEAS Distribution AmbA, Denmark,
Carl Bro, Denmark,
DHI Water and Environment, Denmark,
Tech-wise A/S (now: Elsam Engineering A/S), Denmark.
Sponsor/client: Public Service Obligation, Eltra, Denmark.
Contact: Sten Frandsen, sten.frandsen@risoe.dk, tel. +45 4677 5072.

Fundamentals for Remote Condition Monitoring of Wind Turbine Blades
Programme: VIM, project no. 1120134-00, start date 25.6. 2001, 30.6. 2002.
● In the future, majore wind turbines are most likely to be found in large offshore wind farms and will therefore be relatively inaccessible. Consequently, there will be a need for remote on-shore monitoring of blade integrity. In this project the potential of various sensors is investigated with regard to the assessment of initiation and extension of structural blade damage.
Partners: Materials Research Department, Risø National Laboratory, Denmark,
FORCE Technology, Denmark,
InnospeXion ApS, Denmark,
LM Glasfiber A/S, Denmark.
Sponsor/client: Public Service Obligation (PSO), Denmark.
Contact: Christian Debel, c.p.debel@risoe.dk, tel. +45 4677 5061 or 5819

Contract Concerning Services to Danish Energy Authority
Programme: VIM, project no. 1120299, start date 10.1. 2001, end 2002.
● The primary task is to assist the Danish Energy Authority in managing the 'Danish Approval Scheme for Wind Turbines'. Other activities in 2002 were the maintenance and development of rules and regulations for technical approval of wind turbines. The agreement includes a number of defined activities with individual scopes.
Partners: A number of companies and institutions in Denmark and abroad are involved in these activities as members of an advisory committee, a technical committee and various ad hoc groups.
Sponsor/client: Danish Energy Authority, Denmark.
Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk, tel. +45 4677 5086.

General Programme for Information Activities, International Cooperation, and R&D Related to Standardisation and New Test Methods
Programme: VIM, project no. 1120301, start date 10.1. 2001.
● The programme covers activities that are supplementary to the activities sponsored by the Danish Energy Authority and others. A total of eight different tasks are defined under this internal programme, in which most sections of the Wind Energy Department participate.
Partners: None.
Sponsor/client: None.
Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk, tel. +45 4677 5086.

Wind Turbine Diagnostics, VMD

Research programme
Head of Programme; Jørgen Højstrup

The purpose of this programme is to develop methods for the experimental determination of wind turbine characteristics and to develop methods for meteorological measurements. We also develop test methods for industrial applications, and results are communicated to the wind power industry on a regular basis. Results are to be obtained through a long-term and strategic research effort. Mid-term goals are the development of experimental methods to define

- performance and its interaction with the energy system,
- loads, dynamics and stability,
- aerodynamic flow conditions of full-scale wind turbine rotors, and
- meteorological and chemical processes as well as characteristics of the atmosphere.

Furthermore, we engage in the development and implementation of hardware and software for measuring processes and data management systems.

VMD projects

In 2002, this programme had seven confidential projects.

Experimental Investigation of Ultimate Loads
Programme: VMD, project no. 1125086-00, start date 1.1. 1997, cont.

- The purpose of this project is to support and improve codes and standards by measuring wind field and structural response from wind turbines under extreme conditions (high wind and large wind gusts) and describing extreme events.

Partners: NEG Micon A/S, Denmark.
Sponsor/client: None.
Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk, tel. +45 4677 5043.

Identification of Variables for Site Calibration and Power Curve Assessment in Complex Terrain (Sitepariden)
Programme: VMD, project no. 1125101-00, start date 1.8. 1998, cont.

- The purpose of the Sitepariden project is to reach a better understanding of the parameters affecting power curves in complex terrain as compared to parameters in flat terrain. The project has two major elements:

• Site calibration and power curve assessment of geometrically identical turbines in flat and complex terrain respectively, and
• inter-comparison of the response of various types of cup anemometers used by the project partners – in natural circumstances in flat and complex terrain.

Most tasks have been completed and data analysis has commenced.
Partners: Centre for Renewable Energy Sources (CRES), Greeece,
German Wind Energy Institute (DEWI), Germany,
Windtest, Germany,

Energy research Centre of the Netherlands (ECN), Netherlands,
NEG Micon A/S, Denmark,
Bonus Energy A/S, Denmark.
Sponsor/client: European Commission,
Danish Energy Authority, EFP energy research programme.
Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk, tel. +45 4677 5082.

Adaptation of existing wind turbines for operation on high wind speed complex terrain sites (ADAPTURP)
Programme: VMD, project no. 1125108-00, start date 1.12. 1998, cont.
● The purpose of this project is to examine the entire design envelope of selected wind turbines for operation in complex terrain. This includes the quantification and verification of performance of the adapted stall, and pitch regulated as well as variable speed wind turbines through detailed measurements of wind, loads, power and machine conditions.
Partners: Centre for Renewable Energy Sources (CRES), Greece,
Research Centre for Energy, Environment and Technology (CIEMAT), Spain,
Teknikgruppen AB, Sweden,
Gamesa, Spain,
Energy research Centre of the Netherlands (ECN), Netherlands.
Sponsor/client: None.
Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk, tel. +45 4677 5043.

Performance and Load Measurements on Land and Offshore Installed Wind Turbines without a Meteorological Mast (SODAR)
Programme: VMD, project no. 1125114-00, start date 16.1. 2000.
● The SODAR project explores the possibility of using Sonic Detection And Ranging for measuring wind velocity by means of remote sensing. As wind turbines grow larger, so do expenses associated with the installation of meteorological masts for measuring wind characteristics. During this phase of the project, a SODAR was installed close to Risø's 123 m meteorological mast. We have studied the SODAR and compared results with cup anemometer measurements, and some encouraging results have been obtained.
Partners: None.
Sponsor/client: Danish Energy Authority.
Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk, tel. +45 4677 5082.

Power Performance Measurements
Programme: VMD/PRV, project no. 1155017-02, start date February 2001.
● Power performance measurements on two wind turbines in Italy
Partners: None.
Sponsor/client: Wind turbine manufacturer, Denmark.
Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk, tel. +45 4647 5042.

Small Measuring Stations
Programme: VMD, project no. 1160001-00, start date 20.11. 1997, cont.
● The VMD programme is in charge of the establishment, service and data management of a number of small meteorological measuring stations on behalf of specific projects or as part of the department's long-term strategic measurements.
Partners: None.

Sponsor/client: Internal, and various external sponsors.
Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk, tel. +45 4677 5092.

Risø Mast
Programme: VMD, project no. 1160 003-01, start date 6.6. 1957, cont.
- This programme is in charge of the monitoring of meteorological conditions at Risø National Laboratory (still a nuclear facility) and the establishment of a set of climatological reference data for Denmark. We produce profiles of wind speed and wind direction, air temperature as well as measurements of wind direction variance, relative humidity, barometric pressure, precipitation, duration of sunshine, and insolation. Occasionally, we test various meteorological sensors.

Partners: None.
Sponsor/client: None.
Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk, tel. +45 4677 5092.

Minor Contracts
Programme: VMD, project no. 1160007-1, start date 1.1. 2000.
- These are minor commissions and the supply of measuring equipment. Customers are mainly companies or institutions working with wind energy, meteorology or environmental protection. We have supplied measuring equipment for the technical authorities of the Faroe Islands.

Partners: None.
Sponsor/client: Various.
Contact: Ole Frost Hansen, ole.frost@risoe.dk, tel. +45 4677 5525.

DMU LMP Measuring Stations
Programme: VMD, project no. 1160011-1, start date 1.12. 1999, cont.
- This project concerns the supply of a meteorological station for the LMP (urban monitoring programme), which is a national environmental programme. The station is based on a newly developed data acquisition unit, which digitizes analogue and pulse frequency modulated inputs locally and transfers data serially to a central computer. Furthermore, three current stations will be updated to the level of the new station.

Partners: None.
Sponsor/client: National Environmental Research Institute (NERI), Denmark.
Contact: Ole Frost Hansen, ole.frost@risoe.dk, tel. +45 4677 5525.

South Africa Wind Station
Programme: VMD, project no. 1160013-01 start date 5.4. 2001.
- This project regards the supply of a state-of-the-art automatic battery-powered wind-measuring station for a 30 m mast, recording wind speed statistics, wind direction, air pressure and temperature. The station includes sensors, signal conditioning units, data logger, data storage and data reading equipment. The station is part of project no. 1170113-00, Wind Farm Project Design.

Partners: None.
Sponsor/client: The former Danish Co-operation for Environment and Development (DANCED), now Danida.
Contact: Ole Frost Hansen, ole.frost@risoe.dk, tel. +45 4677 5525.

Cape Verde Wind Stations
Programme: VMD, project no. 1160014-01,start date 3.4. 2001.

- This project concerns the supply of four state-of-the-art automatic battery-powered wind-measuring stations for 30 m masts, recording wind speed statistics and wind direction only. The stations include sensors, signal conditioning units, data logger, data storage and data reading equipment, and they will be used for project no. 1170003-00, Cape Verde Wind Farms 2.

Partners: None.
Sponsor/client: The World Bank.
Contact: Ole Frost Hansen, ole.frost@risoe.dk, tel. +45 4677 5525.

Management of Wind Turbines and Workshop (at The Test Station)
Programme: VMD, project no. 1250002-00, start date 17.1. 2000.

- The purpose of this project is to monitor expenditure and income related to the operation of wind turbines erected at Risø and to some extend expenditure related to the workshop.

Partners: None.
Sponsor/client: NESA, Denmark.
Contact: Per Harvøe, per.harvoe@risoe.dk, tel. +45 4677 5038.

Test Station for Large Wind Turbines, Høvsøre, HØV

Commercial programme
Head; Peter Hjuler Jensen

The objective of this programme is to establish and manage a new test station for large wind turbines at Høvsøre on Jutland's west coast. The test station includes five test beds for wind turbines and five meteorology masts at a position 240 m to the west of the test bed row, which is where the prevailing wind comes from. Another meteorology mast is sited 300 m south of the test bed row, and finally there are two 165 m masts equipped with air traffic warning lights.

By the end of 2002, four wind turbines were erected and ready for testing at the new Test Station at Høvsøre.

HØV projects

Test Station for Large Wind Turbines, Høvsøre

Programme: HØV, project no. 1175001.

- See description under Programme.

Risø Wind Consult, INR

Commercial programme
Head of Programme; Jens Carsten Hansen

Since 1980, Risø Wind Consult has been the coordinating body for the Wind Energy Department's international consultancy tasks. We aim to support the technological development of wind energy, thus improving conditions for the utilization of wind power worldwide. Through our participation in international networks, we seek to connect research to the development of technological applications in future energy supply systems.
Risø WindConsult take on a broad range of tasks with particular emphasis on the preliminary phases of wind power projects and problem complexes that call for new knowledge or further development of standards and methodology. To maintain our capacity as a Danish centre of knowledge in this particular field, we continually develop methods and tools in support of development and analysis of wind power projects and wind farms.

INR projects

Grid-Connected Wind Farm Extension Project, Cape Verde

Programme: INR, project no. 1170003-00, start date 15.3. 2001, cont.
● We render consultation and technical assistance for development and monitoring to the privatised power company Electra, S.A. and the Government of Cape Verde. The project concerns Electra's obligation towards the Government of Cape Verde and the World Bank to expand the capacity of Cape Verde's wind powered electricity generation by installing an additional capacity of up to 4.8 MW, 1.8 MW and 1.2 MW respectively, on the main grids of the islands of Santiago, Sao Vicente and Sal. The project includes five tasks:
- Meteorological measurements.
- Power systems analyses.
- Consulting services for an EPC contract (engineering, procurement and construction).
- Project performance evaluation.
- First year operation and maintenance assistance.

Partners: Carl Bro Gruppen, Denmark,
Tech-wise (subsidiary of Elsam A/S), Denmark.
Sponsor/client: Programa, Energia, Água e Saneamento, Praia, Cape Verde with support from the World Bank, Global Environment Facility (GEF).
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074

Wind Resource Assessment in the Dominican Republic

Programme: INR, project no. 1170006-00, start date 15.9. 2001, cont.
● Our consulting services concern the siting of four masts for wind measurements in potential wind farm areas in the Dominican Republic. This includes the selection of equipment, instrumentation and data processing. We will also provide wind climate documentation after one year of operation as well as supervise measurements continually.

Partners: MetSupport ApS, Denmark.
Sponsor/client: Consorcio Enèrgetico Punta Cana-Macao S.A. (CEPM), Dominican Republic.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

Wind Energy Study for HELCO; the Big Island of Hawaii
Programme: INR, project no. 1170007-00, start date 1.10. 2001, cont.
● INR performs general assessments of the technological and related issues to incorporate increasing levels of wind energy in the isolated electric grid of the island.
Partners: Tech-wise A/S, Denmark.
Sponsor/client: Hawaii Electric Light Company, Inc. (HELCO), Hawaii.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074.

Wind Energy Study in Bermuda
Programme: INR, project no. 1170008-00, start date 20.10. 2001, finalised 2002.
● As a subcontractor to Tech-wise, INR has reviewed and assessed wind measurements made by the client. This includes an elaborate wind resource mapping of potential wind farm sites and a review of the layout and estimated annual energy production of a proposed offshore wind farm.
Partners: Tech-wise (subsidiary of Elsam A/S), Denmark.
Sponsor/client: Bermuda Electric Light Company Ltd. (BELCO), United Kingdom.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

Site Calibration, 60 MW Wind Farm at Zafarana, Egypt
Programme: INR, project no. 1170076-02, start date 1996, cont.
● This project provides a calibration of terrain descriptions for wind flow modelling, using an adaptation of the IEC (International Electrotechnical Commission) site calibration methodology. The site is a 60 MW wind farm at Zafarana, Egypt. Apart from experience gained from the calibration process, this project will also provide useful information about the local conditions for accurate micro-siting of wind turbines. Furthermore, we will collect ample information on wind conditions – including turbulence characteristics – before and after the installation of a wind farm. Only activity in 2002 is data collection. Further data analyses await the completion of the wind farm.
Partners: -
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074.

Capacity Building on the Technological and Economic Integration of Wind Energy and other Relevant Renewable Energy Technologies into the Electricity Systems of Pacific Island Countries
Programme: INR, project no. 1170089-00, start date 25.1. 2000, cont.
● Potential sites for wind turbines will be visited in connection with an expansion of the South Pacific Wind Monitoring Programme. A curriculum and proposals for course material will be developed in close collaboration with regional institutions and teachers. The resulting material will be used for training at the University of South Pacific. Based on findings from previous activities and the installation of a prototype wind turbine for experimental studies and capacity building for selected wind power cases. Tools for this particular type of analysis will be p purposes, a technical, economic and environmental analysis will be carried out.
Sponsor/client: United Nations Environment Programme (rovided and demonstrated.

Partners: UNEP Collaborating Centre on Energy and Environment (UCCEE), located at Risø National Laboratory, Denmark. UNEP), Division of Technology, Industry, and Economics (DTIE); Energy and OzonAction Branch.
Contact: Per Nørgård, per.norgaard@risoe.dk, tel. +45 4677 5068.

Wind Atlas for Egypt
Programme: INR, project no. 1170104-00, start date 19.12.1997, cont.
● The objective of this project is to improve the conditions for large-scale wind power development in Egypt. We will provide the following:
• A wind atlas for Egypt with particular emphasis on regions/locations with attractive wind regimes.
• A comprehensive and updated wind atlas for the Gulf of Suez.
• A decision tool for environmental impacts, especially concerning bird migration.
• Recommendations for a common framework of wind farm planning in the Gulf of Suez.
• A transfer of knowledge and experience to Egyptian partners regarding the methodology applied to establishing a wind atlas.
Partners: Ornis Consult A/S, Denmark,
National Environmental Research Institute (NERI), Denmark.
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074.

NREA/Danida 60 MW Wind Farm Project at Zafarana, Egypt
Programme: INR, project no. 1170106-00, start date January 1998, cont.
● As subcontractor to COWI A/S we act as consultants to NREA (New and Renewable Energy Authority, Egypt) and Danida, and provide the following;
• Pre-award phase: Proposals for the layout and siting of wind turbines, calculation of energy outputs, recommendations for optimum use of land, and review of power performance estimates as submitted by the tenders.
• Design phase: Preparation of a iled layout of the wind farm including optimisation of annual energy deta.
• Construction phase: Definition and output review of the power curve verification completed by an independent third party.
Partners: COWI A/S, Denmark.
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074.

National Wind Turbine Test Station, India
Programme: INR, project no. 1170111-00, start date 1.1. 1999, cont.
● The main objective of this project is to promote and accelerate the utilisation of wind power in India by establishing national facilities for testing and certification of wind turbines, for the preparation of standards and certification rules and for monitoring the technical performance of wind turbines. Initially, a core professional organisation as well as facilities for stationary and field power performance measurements have been established and a preliminary type approval system has been developed. Major components in the project include institutional development, workshops and on-the-job training for local staff during testing and certification, and technical support with regard to equipment and facilities.
Partners: Det Norske Veritas (DNV), Norway,
PEM Consult, Denmark,

NIRAS – Rådgivende Ingeniører og Planlæggere A/S, Denmark.
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Per Lundsager, per.lundsager@risoe.dk, tel. +45 4677 5045.

Demonstration Wind Farm Project Design, South Africa
Programme: INR, project no. 1170113-00, start date 22.1. 1999, cont.
● As subcontractor to Rambøll, we have assisted DANCED in its efforts to support the initiation of a demonstration wind farm project in Darling, Western Cape, South Africa. During 2001 an on-site wind measurement programme has been initiated with equipment supplied by Risø. We also assist with the preparation of plans for tendering and implementation of the wind farm.
Partners: Rambøll, Denmark,
Council for Scientific and Industrial Research (CSIR), South Africa,
Darling Independent Power Producer (DARLIPP), South Africa,
Sponsor/client: Danish Cooperation for Environment and Development (DANCED), Denmark.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074

Energy Management in Lesotho – Wind Energy Advisor
Programme: INR, project no. 1170116-00, start date 25.1. 2000, cont.
● The objectives of this project are:
• To assist Lesotho authorities in the identification of areas with wind energy potential.
• To asses wind resources in selected areas of Lesotho and present results in a wind atlas format.
• To apply the results of wind resource assessment to a selected wind power project feasibility study.
• To contribute to a wind energy programme as part of the Lesotho Energy Master Plan.
Three sets of measurement equipment have been supplied and installed. Measurements at selected sites are to carry on for one year, and data analyses and a feasibility study will be produced subsequently.
Partners: Rambøll, Denmark.
Sponsor/client: Danish Cooperation for Environment and Development (DANCED), Denmark.
Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk, tel. +45 4677 5074.

Wind Measurements and Wind Power Feasibility at Selected Sites in Tanzania
Programme: INR, project no. 1170118-00, start date 1.1. 2000, cont.
● The objectives of the assignment are as follows:
• To provide the tools and build the capacity in Tanzania to enable wind resource assessment, adequate for determining the feasibility of wind power utilisation at selected locations.
• To determine the feasibility of establishing a pilot wind farm connected to the public power supply system in one of four pre-selected localities.
Four sets of measurement equipment have been supplied and installed. Measurements at the pre-selected sites are to carry on for one year after which data analyses and a feasibility study will be produced.
Partners: Tanzania Electric Supply Company, Ltd. (TANESCO), Tanzania,
Tanzania Ministry of Energy.
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Per Nørgård, per.norgaard@risoe.dk, tel. +45 4677 5068

Ghana Wind Resource Assessment Project
Programme: INR, project no. 1170119-00, start date 19.1. 2001.

● The primary aim of this project is to consolidate ongoing efforts to identify and assess Ghana's wind energy potential. This means strengthening the national stakeholders' capabilities through support to the Ghanaian Meteorological Services Department and similar institutions; the Ghana Energy Commission, The Ministry of Mines and Energy, the Kwame Nkrumah University of Science and Technology, and possibly relevant private consultants.
Partners: Ghana Ministry of Energy,
Ghana Energy Commission,
Kwame Nkrumah University of Science and Technology, Ghana.
Sponsor/client: Danish International Development Assistance (Danida), Denmark.
Contact: Per Nørgård, per.norgaard@risoe.dk, tel. +45 4677 5068.

El Cayo, Spain
Programme: INR, project no. 1170009-00, start date 1.12. 2001, finalised 2002.
● We have been engaged to assess extreme winds and turbulence levels at a proposed wind farm site in complex terrain. The assignment includes a lifetime evaluation of wind turbines in the wind farm.
Partner: -
Sponsor/client: NEG Micon A/S, Denmark.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

Investigation of Wind Turbines
Programme: INR, project no. 1170010-00, start date 8.2. 2002, finalised in 2002.
● Confidential project.
Partner: -
Sponsor/client: Wescare, India.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

Karnataka, India
Programme: INR, project no. 1170014-00, start date 15.8. 2002, finalised in 2002.
● This assignment concerns the assessment of wind resource and estimation of annual energy production from a wind farm located in Bab Budan Hills, Karnataka.
Partner: -
Sponsor/client: GI Wind Farms, India.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

95 MW Wind Farm at Pampilhosa, Portugal
Programme: INR, project no. 1170015-00, start date: 1.10. 2002, cont.
● Review of project contractual basis i.e. the EPC contract (engineering, procurement, and construction) with the turnkey contractor, the operation and maintenance agreement and the warranty agreement; review of certification of the wind turbines and verification of annual energy production estimate.
Partner: Tech-wise (subsidiary of Elsam A/S), Denmark.
Sponsor/client: Galp Energia, SGPS, SA, Portugal.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

GI Wind Farm in Maharashtra
Programme: INR, project no. 1170011-00, start date 1.3. 2002, finalised 2002.

● Acting as owner's engineer for GI Wind Farms, we are to review the project's contractual basis; i.e. the EPC (engineering, procurement, construction) contract with the turnkey contractor, the operation, maintenance and warranty agreement and the PPA (power purchase agreement). Furthermore, we are to review the certification status of the wind turbines and their fitness to the site; to verify performance tests of the two wind farms and finally review completion of the project.
Partner: Tech-wise (subsidiary of Elsam A/S), Denmark.
Sponsor/client: GI Wind Farms, India.
Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk, tel. +45 4677 5079.

Wind Turbine Testing, VMD/PRV

Commercial programme
Head; Søren Markkilde Petersen

The objective of this programme is to perform scientifically based, internationally accredited testing of wind turbines in connection with type approval, documentation and support of industrial development.

VMD/PRV projects

The main activity of this programme is testing of various parts of wind turbines on a commercial basis and therefore confidential. In 2002 there were 18 confidential projects.

Sparkær Blade Test Centre, SPK

Commercial programme
Head; Carsten Skamris

The purpose of this programme is
- to determine dynamic characteristics, and to conduct static and fatigue testing of wind turbine blades as well as other experimental investigations as a commercial enterprise for the wind turbine industry,
- to develop new, more efficient and informative methods for blade testing,
- to participate in various Risø research projects, involving experimental investigation of blades.

SPK projects

Blade Testing, LM Glasfiber A/S
Programme: SPK, project no. 1165001, start date 14.1. 2000.
- The Sparkær Centre is an accredited test laboratory for wind turbine blades. The strength of blade static as well as fatigue is tested. Dynamic behaviour, such as natural frequencies and damping are also measured. Tests are carried out at the Wind Energy Department's facilities in Sparkær, Jylland, and as field measurements.

Partners: None.
Sponsor: None.
Customer: LM Glasfiber A/S.
Contact: Carsten Skamris, c.skamris@risoe.dk, tel. +45 4677 5066.

Blade Testing, Vestas Wind Systems A/S
Programme: SPK, project no. 1165002, start date 14.1. 2000.
- The Sparkær Centre is an accredited test laboratory for wind turbine blades. The strength of blade static as well as fatigue is tested. Dynamic behaviour such as natural frequencies and damping are also measured. Tests are carried out at the Wind Energy Department's facilities in Sparkær, Jylland.

Partners: None.
Sponsor: None.
Customer: Vestas Wind Systems A/S
Contact: Carsten Skamris, c.skamris@risoe.dk, tel. +45 4677 5066.

Development and Verification of Methods for Determining Modal Shapes of Wind Turbine Blades
Programme: SPK, project no. 51171/01-0011, start date 1.11. 2001, end 31.12. 2002.
- The scope of this project is to make modal analysis practicable by developing the method as well as the equipment. Furthermore, we hope to obtain useful and reproducible results. There is particular focus on equipment, software and measuring method including survey of the blade, the principle of excitation and mounting of the blade on the test rig.

Partners: None.

Sponsor: Renewable energy programme (UVE), Danish Energy Authority.
Contact: Henrik Broen Pedersen, henrik.broen.pedersen@risoe.dk, tel. +45 8664 5600

Committee and Expert Group Memberships

Antoniou. I.
Technical Committee 88, Maintenance Team 11; Acoustic noise measurement technique. International Electrotechnical Commission (IEC).

Barthelmie, R.
Technical Committee and Poster Award Committee, Offshore Wind Energy in Mediterranean and Other European Seas Conference.
Atmospheric Aerosols Working Group, American Association for Aerosol Research.

Bjerregaard, E.T.D.
Secretary, Technical Committeee and Advisory Committee, the Danish Approval Scheme for Wind Turbines, Danish Energy Authority.
Standardization committee S-588; Elproducerende vindmøller (power generating wind turbines), Danish Standards Association.
Joint Research Centre's (JRC) Core Group for Scientific Technical Reference System on Renewable Energy and Energy End-Use Efficiency.

Buhl, T.
External member, Danish Center for Applied Mathematics and Mechanics, Technical University of Denmark.

Clausen, N.-E.
Corps of external examiners, Technical University of Denmark.

Frandsen, S.
Technical Committee 88, Maintenance Team 12; Wind turbine power performance testing, and Working Group 3; Design requirements for offshore wind turbines, International Electrotechnical Commission (IEC).
Standardization committee S-588; Elproducerende vindmøller (power generating wind turbines), Danish Standards Association.

Gryning, S.E.
Associate editor, 'Quarterly Journal of the Royal Meteorological Society'.
Baltic Sea Experiment (BALTEX) Science Steering Group and conference committee; Fourth Study Conference on BALTEX.
International Scientific Advisory Committee, Conference on Modelling, Monitoring and Management of Air Pollution. Wessex Institute of Technology.
Secretary, European Association for the Science of Air Pollution (EURASAP).
Chairman, Executive Committee, Northern Hemisphere Climate Processes Land-Surface Experiment (Nopex).
International Scientific Committee, the International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes.
Scientific Steering Committee, NATO/CCMS International Technical Meetings on Air Pollution Modelling and Its Application (conference series).
Editorial Advisory Board, 'Bulgarian Geophysical Journal'.

Hansen, M.H.

External member, Danish Center for Applied Mathematics and Mechanics, Technical University of Denmark.

Hasager, C.B.

Corps of external examiners, University of Copenhagen.
Corps of external examiners, Roskilde University Centre (RUC).
Convenor, symposium on air/land interactions; European Geophysical Society and American Geophysical Union joint assembly.
Organizing representative, Working Group on Remote Sensing, and *national EC-representative*, Working Group on Remote Sensing, Applications on Forest Health Assessment. European Commission.
Applications Committee, Committee on Space Research (COSPAR) 34th Scientific Assembly, USA.
Treasurer, Danish User Group, Erdas Imagine.
Associate scientist, Surface Processes and Ecosystems Changes through Response Analysis (SPECTRA). A land surface satellite space mission proposal for the years 2005-. European Space Proposal.

Hauge Madsen, P.

Chairman, standardization committee S-588; Elproducerende vindmøller (power generating wind turbines), Danish Standards Association.
Convenor, Technical Committee 88, Maintenance Team 1; Safety of wind turbines, and member, Working Group 3; Design requirements for offshore wind turbines, International Electrotechnical Commission.
Committee on European standards for wind turbines, European Committee for Electrotechnical Standardization (CENELEC).
Board member, Society of Fuel and Energy Technology, The Society of Danish Engineers (IDA).
Editorial Board, 'Wind Energy', Wiley & Sons.
Wind Energy Advisory Committee, Danish Energy Authority.
Committee on the Implementation of IEC-standards in the Danish Type Approval Scheme, Danish Energy Authority.
National member, R&D Wind Executive Committee, International Energy Agency (IEA).

Hjuler Jensen, P.

Expert Committee on Wind Turbines, Det Norske Veritas (DNV).
Expert Committee on Wind Turbines, Germanischer Lloyd.
Technical Committee 88; Maintenance Team 1; Safety of wind turbines, International Electrotechnical Commission (IEC).
Committee on Criteria for Design and Certification of Wind Turbines, Danish Energy Authority.
Vice-president, European Wind Energy Association (EWEA).
Committee on European standards for wind turbines, European Committee for Electrotechnical Standardization (CENELEC).

Højholdt, P.

Technical Committee, Domestic Wind Turbines, Danish Energy Authority.

Højstrup, J.

Vice-chairman, Executive Board; Measuring Network of Wind Energy Institutes (MEASNET).

Jensen, N.O.

National Committee, International Union of Theoretical and Applied Mechanics (IUTAM).

National Committee for the International Geosphere-Biosphere Programme (IGBP).
Editorial Board, 'Boundary-Layer Meteorology'.
President, The International Commission on Dynamical Meteorology (ICDM) under The International Association of Meteorology and Atmospheric Sciences (IAMAS).
Scientific Advisory Group, Pan-European Programme for the Intensive Monitoring of Forest Ecosystems. EC and UN/ECE.
Jørgensen, E.R.
Steering Committee, Wind Turbine Certification, Det Norske Veritas (DNV).

Jørgensen, H.E.
Vice-president, Dansk Meteorologisk Selskab (the Danish meteorological society).

Kristensen, L.
Associate editor, 'Quarterly Journal of Royal Meteorological Society'.

Krogsgaard, J.
Editorial Committee, Atlas of European Small-Scale Hydropower Potential, European Small Hydropower Association (ESHA).
Governing Council, European Small Hydropower Association (ESHA).
Editorial Committee, Energy for a Free Europe, EU Altener II Programme.

Landberg, L.
Steering Committee, Offshore Wind Energy Network, UK.
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Rasmussen, F.; Thomsen, K.; Larsen, T.J., Patent application. DK patentansøgning PA 2002 01377.

Educational activities

Bak, C. *Aeroelasticity and Aerodynamics*, course SEE8-5; Wind Power Technology, Aalborg University, February 2002.
Dynamic Stall, course 41322; Aeroelasticity for Wind Turbines, Technical University of Denmark, February 2002.

Barthelmie, R. Member of graduate supervision committee. Supervising Justin Schoof, PhD, Indiana University.

Fuglsang, P. *Airfoil Design*; lecture at Mie University, Japan, 20 September 2002.
Aerodynamics of Wind Turbine Rotors; lecture at Mie University, Japan, 19 September 2002. Unpublished.
An Introduction to Risø National Laboratory; Aeroelastic Research. Lecture at Mie University, Japan, 18 September 2002. Unpublished.
Wind Energy in Denmark, Offshore Wind Energy in Europe. Lecture at Mie University, Japan, 17 September 2002. Unpublished.

Hasager, C.B. External examiner, remote sensing, University of Copenhagen, 8 January and 6 June 2002.
External examiner, climatology and remote sensing, BSC and MSc levels, University of Copenhagen, 20 June 2002.
External examiner, climatology, MSc level, University of Copenhagen, 26 June and 13 August 2002.
External examiner, remote sensing and GIS (geographic information system), University of Copenhagen, 29 August 2002.
Satellite Images of the Earth (in Danish), Dansk Naturvidenskabsfestival, 27 September – 6 October 2002.

Landberg, L. *Wind Power Meteorology*, Technical University of Denmark, 24 October 2002.
Wind Energy and Meteorology, Technical University of Denmark, 24 October 2002.
WasP courses at Risø 9-11 April, Tokyo, Japan 29-31 July, Beijing, China 14-18 October, and Risø 25-27 November, 2002.
Wind Power Meteorology, Ecole Nationale Supérieure des Mines de Paris, Nice, France, 22 November 2002.

Sørensen, L.L. *Atmospheric Science and Air Pollution*, Aalborg University, Denmark, 7-11 October 2002.

Sørensen, P. *Wind Power Technology; Technology Overview*. Lecture at MSc course in sustainable energy engineering, Institute of Energy Technology at Aalborg University, Denmark, 11

February 2002. Unpublished.
Wind Power Technology; Wind Energy Development and Technical Challenges. Lecture at MSc course in sustainable energy engineering, Institute of Energy Technology at Aalborg University, 11 February 2002. Unpublished.

Thomsen, K. *Wind Turbine Design Loads*. Lecture at MSc course in wind energy, Technical University of Denmark.
Using Aeroelastic Models FLEX5 and HAWC. Tuition at Herning Institute of Business Administration and Technology, 1-2 October 2002.
Fatigue and extreme load analysis. Tuition at Herning Institute of Business Administration and Technology, 7-8 October 2002.

Seminars in the Department

The Department has a tradition of internal Tuesday-seminars, presented by staff or guests.

15 January
Charlotte Bay Hasager: *Satellite-based roughness maps used in HIRLAM.*

29 January
Niels Otto Jensen: *Area-representative values of z0t.*

5 February
Hans E. Jørgensen: *Concentration fluctuations and self-similarity.*

26 February
Søren Thykier-Nielsen and Valena Coelho Olsen: *Øresund revisited.*

5 March
Sven-Erik Gryning: *Fluxes in the Baltic area.*

19 March
Sara Pryor: *Particle fluxes in the marine boundary layer.*

30 April Torben Mikkelsen: *Similarity scaling of the lateral diffusivity in the surface layer: application for puffs and plumes.*

7 May
Rebecca Barthelmie: *On SODAR and wakes.*

21 May
Jørgen Højstrup: *Misuse of WASP in complex terrain; expensive experiences from real life.*

July
J.A. Dutton: *Buying better weather; new financial strategies for managing weather and climate risk.*

3 September
Torben Mikkelsen: *Foot- and mouth disease, UK 2001.*

10 September
Lotte Sørensen: *Application of REA systems for HNO_3 and NH_3.*

17 September
Helge Madsen: *Modelling of yaw aerodyamics.*

24 September
Gregor Giebel: *CleverFarm; the wind farm on the web.*

8 October
Morten Nielsen: *Concentration fluctuations in surface-layer plumes.*

22 October
Franck Bertagnolio: *Fluid/struktur kobling og aeroelastiske beregninger.*

November
Ann-Sofi Smedmann: *The marine atmospheric boundary layer; new findings from the Östergarnsholm station in the Baltic Sea.*

5. November: *Modelling of yaw aerodynamics.*

14. November
Larry Mahrt: *Observations of the stable boundary layer.*

15. November
Xavier Kornmann: *Active fibre composites, sensors and actuators for adaptive materiale systems.*

19. November
Niels Gylling Mortensen: *Commercial wind power meteorology: Wind resources and wind conditions in Cape Verde.*

Assignments and Awards

Petersen, E.L.
DONG's (Dansk Olie & Naturgas) Annual Award 2002.

Staff and Guests

Staff

Administration

Clausen, Gitte, *Project Administrator*
Hyllested, Karen, *Administrative Officer*
Harvøe, Per, *Administrative Officer*
Madsen, Peter Hauge, *Deputy Head of Department*
Petersen, Erik Lundtang, *Head of Department*

Secretaries

Christiansen, Ulla Riis
Sørensen, Else Holst, *Temporary Assistant*
Holm, Jette, *Junior Clerk*

Aeroelastic Design (AED)

Scientific staff

Bak, Christian
Bertagnolio, Franck
Buhl, Thomas
Fuglsang, Peter
Gaunaa, Mac
Hansen, Anders Melchior
Hansen, Morten, Hartvig
Johansen, Jeppe
Larsen, Gunner Chr.
Larsen, Torben Juul
Madsen, Helge Aagaard
Flemming Rasmussen, *Head of Programme*
Sørensen, Niels Nørmark
Thomsen, Kenneth

PhD students, graduates, and postdoctoral researchers etc.

Zahle, Frederik, student

Secretary

Precht, Tina

Atmospheric Physics (ATM)

Scientific staff

Astrup, Poul
Gryning, Sven Erik
Hasager, Charlotte Bay
Jensen, Niels Otto
Jørgensen, Hans
Larsen, Søren, *Head of Programme*
Mikkelsen, Torben, *Research Expert*

Nielsen, Morten
Pryor, Sara, *Guest*
Sørensen, Lise Lotte
Thykier-Nielsen, Søren

PhD students, graduates, and postdoctoral researchers

Dellwik, Ebba
Dunkerley, Fay
Frohn Lise (in a collaboration with NERI)
Nissen, Jesper

Secretary

Skrumsager, Birthe (retired 1 November)

Electrical Design and Control (EDS)

Scientific staff

Bindner, Henrik W.
Jauch, Clemens
Hansen, Anca Daniela
Hauge Madsen, Peter, *Head of Programme*
Nørgaard, Per
Pulle, Duco W.J.
Sørensen, Poul

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Rasmussen, Mikkel Hjortshøj
Rosas, Pedro André

Secretary

Madsen, Jytte

Risø Wind Consult (INR)

Clausen, Niels Erik
Hansen, Jens Carsten, *Head of Programme*
Jørgensen, Lars *(from Danida)*
Lundsager, Per

Secretary

Kiler, Diana

Wind Power Meteorology (VKM)

Scientific staff

Badger, Jake
Barthelmie, Rebecca
Giebel, Gregor
Jørgensen, Bo Hoffmann
Landberg, Lars, *Head of Programme*
Mann, Jakob
Mortensen, Niels Gylling
Myllerup, Lisbeth

Nedaud, Cyril
Ott, Søren
Rathmann, Ole
Sempreviva, Anna Maria

PhD students, graduates, and postdoctoral researchers

Corbett, Jean-Francois

Sales co-ordinator

Nielsen, Rikke

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Wind Turbines (VIM)

Scientific staff

Bjerregaard, Egon
Debel, Christian
Frandsen, Sten Tronæs
Højholdt, Poul
Jensen, Find Mølholt
Jensen, Peter Hjuler, *Head of Programme*
Jørgensen, Erik Rosenfeldt
Krogh, Thomas
Schaarup, Jesper
Tarp-Johansen, Niels Jacob

PhD students, graduates, and postdoctoral researchers

None

Technical staff

Lange, Rolf

Secretaries

Bødker, Bodil
Westermann, Kirsten

Wind Turbine Diagnostics (VMD)

Scientific staff

Antoniou, Ioannis
Enevoldsen, Karen
Hansen, Ole Frost
Højstrup, Jørgen, *Head of Programme*
Krogsgaard, Jørgen
Møller, René
Nielsen, Troels Eske
Paulsen, Uwe Schmidt
Pedersen, Troels Friis, *Research Expert*
Petersen, Søren Markkilde, *Head of Task*
Sanderhoff, Peter
Vesth, Allan

Technical staff

Andersen, Anker Bruun
Borchsenius, Jens
Christensen, Kurt
Christensen, Lars
Clemmensen, Kaspar
Hansen, Finn
Hansen, Per
Høst, Oluf
Jensen, Gunnar (retired 1 May 2002)
Larsen, Gert
Lund, Søren W.
Nielsen, Finn Linke
Nielsen, Jan
Rasmussen, Michael

Secretary

Hansen, Anne-Marie
Henriksen, Mette Porsdal

Sparkær Centre (Type Approval and Certification) (SPK)

Eisenberg, Yoram
Hornbech, Jan
Kristensen, Ole Dahl
Pedersen, Henrik Broen
Skamris, Carsten, *Head of Task*
Thomsen, Christian Leegaard

Technical staff

Foget, Mads Holler
Lind, Peter Henrik, *Works Foreman*
Stær, Jimmy Holm
Vestergaard, Anders Ramsing

Secretary

Kristensen, Bente Hangaard

Guests

Chekuri, Chandra S.; Chennai, India, from 15.4. to 15.7. 2002.
Holttinen, Hannele; VTT Technical Research Centre of Finland, Finland, from 24.6. to 12.7. 2002.
Olsen, Valena Coelho; Carl Bro, Aarhus, Denmark, from 1.1. to 31.3. 2002.
Pryor, Sara; Indiana University, USA, from 8.5. to 31.8. 2002.

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Abstract: This report covers the scientific work of the Wind Energy Department in 2002. It contains departmental programmes as well as brief summaries of all non-confidential projects and a review of this year's key issues.

Wind Energy Department 2002 in brief

The overall objective of the Wind Energy Department is to create new opportunities for technological development and the utilization of wind energy through research, innovation, education, testing, and consultancy.

Our research and development activities cover a variety of topics from boundary layer meteorology and fluid dynamics to structural mechanics, power and control engineering as well as wind turbine loading and safety. It is our aim to meet the needs for knowledge, methods and consultancy assistance in relation to wind energy, and we are involved in technology development as well as operation and maintenance, testing, and certification of wind turbines. Furthermore, we look into technical problems related to the application of wind energy. A major part of this work is carried out on a commercial basis.

Department activities also include research into environmental issues related to the atmosphere.

Organization

Department management:

Erik Lundtang Petersen, Head (ext. 5001)
Peter Hauge Madsen, Deputy Head (ext. 5011)

Research is organized in the following programmes:

Atmospheric Physics
Søren Larsen, Head (ext. 5012)

Wind Power Meteorology
Lars Landberg, Head (ext. 5024)

Aeroelastic Design
Flemming Rasmussen, Head (ext. 5048)

Electrical Design & Control
Peter Hauge Madsen, Head (ext. 5011)

Wind Turbines
Peter Hjuler Jensen, Head (ext. 5037)

Wind Turbine Diagnostics
Jørgen Højstrup, Head *(*ext. 5092*)*

Commercial activities are:

Wind Turbine Testing
Søren Markkilde Petersen, Head (ext. 5043)

Sparkær Blade Test Centre
Carsten Skamris, Head (ext. 5066)

Risø Wind Consult
Jens Carsten Hansen, Head (ext. 5074)

Publications

Refereed international publications	58
International books and reports	5
Danish books and reports	130
Conference papers with proceedings	67
Patent applications	1

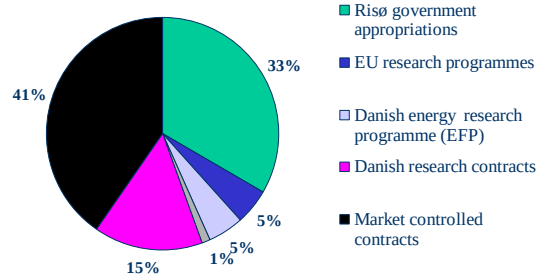
Finances

Turnover	DKK 98.6 million
Contracts, market controlled	DKK 39.8 million
Contracts, grant controlled	DKK 25.5 million

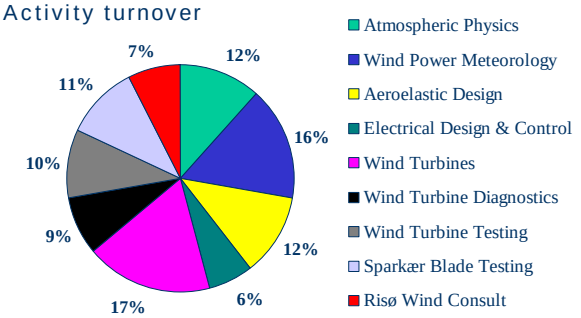
Staff

Academic staff	78
Technical/administrative staff	29
PhD and postdocs	2

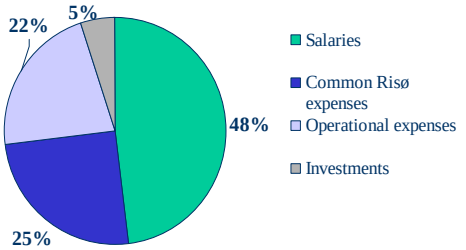
Funding sources



Activity turnover



Expenses



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